	EPA I.D. NUMBER (enter from page 1)		FOR OFFICIAL USE ONLY	
W M I D 9 8 0 5 6 8 7 1 1 · 1			W	DUP	2 DUP

IV. DESCRIPTION OF HAZARDOUS WASTES (continued)

U	A. EPA HAZARD. WASTE NO. (enter code)	B. ESTIMATED ANNUAL QUANTITY OF WASTE	C. UNIT OF MEASURE (enter code)	D. PROCESSES 1. PROCESS CODES (enter)	2. PROCESS DESCRIPTION (if a code is not entered in D(1))
1	P 1 2 1	1,000	T	D 8 0	
2	P 1 2 2	1,000	T	D 8 0	
3	P 1 2 3	1,000	T	D 8 0	
4	U 0 0 1	1,000	T	D 8 0	
5	U 0 0 2	1,000	T	D 8 0	
6	U 0 0 3	1,000	T	D 8 0	
7	U 0 0 4	1,000	T	D 8 0	
8	U 0 0 5	1,000	T	D 8 0	
9	U 0 0 6	1,000	T	D 8 0	
10	U 0 0 7	1,000	T	D 8 0	
11	U 0 0 8	1,000	T	D 8 0	
12	U 0 0 9	1,000	T	D 8 0	
13	U 0 1 0	1,000	T	D 8 0	
14	U 0 1 1	1,000	T	D 8 0	
15	U 0 1 2	1,000	T	D 8 0	
16	U 0 1 4	1,000	T	D 8 0	
17	U 0 1 5	1,000	T	D 8 0	
18	U 0 1 6	1,000	T	D 8 0	
19	U 0 1 7	1,000	T	D 8 0	
20	U 0 1 8	1,000	T	D 8 0	
21	U 0 1 9	1,000	T	D 8 0	
22	U 0 2 0	1,000	T	D 8 0	
23	U 0 2 1	1,000	T	D 8 0	
24	0 2 2	1,000	T	D 8 0	
25	U 0 2 3	1,000	T	D 8 0	
26	U 0 2 4	1,000	T	D 8 0	

CONTINUE ON REVERSE

	EPA I.D. NUMBER (enter from page 1)			FOR OFFICIAL USE ONLY	

W M I D 9 8 0 5 6 8 7 1 1 · 1

W   DUP   2 DUP

IV. DESCRIPTION OF HAZARDOUS WASTES (continued)

	A. EPA HAZARD. WASTE NO. (enter code)	B. ESTIMATED ANNUAL QUANTITY OF WASTE	C. UNIT OF MEASURE (enter code)	D. PROCESSES				
				1. PROCESS CODES (enter)				2. PROCESS DESCRIPTION (if a code is not entered in D(1))
1	U 0 2 5	1,000	T	D 8 0				
2	U 0 2 6	1,000	T	D 8 0				
3	U 0 2 7	1,000	T	D 8 0				
4	U 0 2 8	1,000	T	D 8 0				
5	U 0 2 9	1,000	T	D 8 0				
6	U 0 3 0	1,000	T	D 8 0				
7	U 0 3 1	1,000	T	D 8 0				
8	U 0 3 2	1,000	T	D 8 0				
9	U 0 3 3	1,000	T	D 8 0				
10	U 0 3 4	1,000	T	D 8 0				
11	U 0 3 5	1,000	T	D 8 0				
12	U 0 3 6	1,000	T	D 8 0				
13	U 0 3 7	1,000	T	D 8 0				
14	U 0 3 8	1,000	T	D 8 0				
15	U 0 3 9	1,000	T	D 8 0				
16	U 0 4 1	1,000	T	D 8 0				
17	U 0 4 2	1,000	T	D 8 0				
18	U 0 4 3	1,000	T	D 8 0				
19	U 0 4 4	1,000	T	D 8 0				
20	U 0 4 5	1,000	T	D 8 0				
21	U 0 4 6	1,000	T	D 8 0				
22	U 0 4 7	1,000	T	D 8 0				
23	U 0 4 8	1,000	T	D 8 0				
2	U 0 4 9	1,000	T	D 8 0				
25	U 0 5 0	1,000	T	D 8 0				
26	U 0 5 1	1,000	T	D 8 0				

CONTINUE ON REVERSE

Continued from page 2.
NOTE: Photocopy this page before completing if you have more than 26 wastes to list.

EPA I.D. NUMBER	FOR OFFICIAL USE ONLY
W M I D 9 8 0 5 6 8 7 1 1 · 1	W DUP 2 DUP

IV. DESCRIPTION OF HAZARDOUS WASTES (continued)

LINE	A. EPA HAZARD. WASTE NO. (enter code)	B. ESTIMATED ANNUAL QUANTITY OF WASTE	C. UNIT OF MEASURE (enter code)	D. PROCESSES 1. PROCESS CODES (enter)	2. PROCESS DESCRIPTION (if a code is not entered in D(1))
1	U052	1,000	T	D 8 0	
2	U053	1,000	T	D 8 0	
3	U055	1,000	T	D 8 0	
4	U056	1,000	T	D 8 0	
5	U057	1,000	T	D 8 0	
6	U058	1,000	T	D 8 0	
7	U059	1,000	T	D 8 0	
8	U060	1,000	T	D 8 0	
9	U061	1,000	T	D 8 0	
10	U062	1,000	T	D 8 0	
11	U063	1,000	T	D 8 0	
12	U064	1,000	T	D 8 0	
13	U066	1,000	T	D 8 0	
14	U067	1,000	T	D 8 0	
15	U068	1,000	T	D 8 0	
16	U069	1,000	T	D 8 0	
17	U070	1,000	T	D 8 0	
18	U071	1,000	T	D 8 0	
19	U072	1,000	T	D 8 0	
20	U073	1,000	T	D 8 0	
21	U074	1,000	T	D 8 0	
22	U075	1,000	T	D 8 0	
23	U076	1,000	T	D 8 0	
24	U077	1,000	T	D 8 0	
25	U078	1,000	T	D 8 0	
26	U079	1,000	T	D 8 0	

CONTINUE ON REVERSE

EPA I.D. NUMBER (enter from page 1)		FOR OFFICIAL USE ONLY	
W M I D 9 8 0 5 6 8 7 1 1 · 1		W DUP	2 DUP

IV. DESCRIPTION OF HAZARDOUS WASTES (continued)

L Z	A. EPA HAZARD. WASTE NO. (enter code)	B. ESTIMATED ANNUAL QUANTITY OF WASTE	C. UNIT OF MEASURE (enter code)	D. PROCESSES 1. PROCESS CODES (enter)				2. PROCESS DESCRIPTION (if a code is not entered in D(1))
1	U 0 8 0	1,000	T	D 8 0				
2	U 0 8 1	1,000	T	D 8 0				
3	U 0 8 2	1,000	T	D 8 0				
4	U 0 8 3	1,000	T	D 8 0				
5	U 0 8 4	1,000	T	D 8 0				
6	U 0 8 5	1,000	T	D 8 0				
7	U 0 8 6	1,000	T	D 8 0				
8	U 0 8 7	1,000	T	D 8 0				
9	U 0 8 8	1,000	T	D 8 0				
10	U 0 8 9	1,000	T	D 8 0				
11	U 0 9 0	1,000	T	D 8 0				
12	U 0 9 1	1,000	T	D 8 0				
13	U 0 9 2	1,000	T	D 8 0				
14	U 0 9 3	1,000	T	D 8 0				
15	U 0 9 4	1,000	T	D 8 0				
16	U 0 9 5	1,000	T	D 8 0				
17	U 0 9 6	1,000	T	D 8 0				
18	U 0 9 7	1,000	T	D 8 0				
19	U 0 9 8	1,000	T	D 8 0				
20	U 0 9 9	1,000	T	D 8 0				
21	U 1 0 1	1,000	T	D 8 0				
22	U 1 0 2	1,000	T	D 8 0				
23	U 1 0 3	1,000	T	D 8 0				
24	1 0 5	1,000	T	D 8 0				
25	U 1 0 6	1,000	T	D 8 0				
26	U 1 0 7	1,000	T	D 8 0				

CONTINUE ON REVERSE

	EPA I.D. NUMBER (enter from page 1)		FOR OFFICIAL USE ONLY		
	W M I D 9 8 0 5 6 8 7 1 1 · 1	T/A C	W	DUP	2 DUP

IV. DESCRIPTION OF HAZARDOUS WASTES (continued)

	A. EPA HAZARD. WASTE NO. (enter code)	B. ESTIMATED ANNUAL QUANTITY OF WASTE	C. UNIT OF MEA-SURE (enter code)	D. PROCESSES 1. PROCESS CODES (enter)				2. PROCESS DESCRIPTION (if a code is not entered in D(1))
1	U 1 0 8	1,000	T	D 8 0				
2	U 1 0 9	1,000	T	D 8 0				
3	U 1 1 0	1,000	T	D 8 0				
4	U 1 1 1	1,000	T	D 8 0				
5	U 1 1 2	1,000	T	D 8 0				
6	U 1 1 3	1,000	T	D 8 0				
7	U 1 1 4	1,000	T	D 8 0				
8	U 1 1 5	1,000	T	D 8 0				
9	U 1 1 6	1,000	T	D 8 0				
10	U 1 1 7	1,000	T	D 8 0				
11	U 1 1 8	1,000	T	D 8 0				
12	U 1 1 9	1,000	T	D 8 0				
13	U 1 2 0	1,000	T	D 8 0				
14	U 1 2 1	1,000	T	D 8 0				
15	U 1 2 2	1,000	T	D 8 0				
16	U 1 2 3	1,000	T	D 8 0				
17	U 1 2 4	1,000	T	D 8 0				
18	U 1 2 5	1,000	T	D 8 0				
19	U 1 2 6	1,000	T	D 8 0				
20	U 1 2 7	1,000	T	D 8 0				
21	U 1 2 8	1,000	T	D 8 0				
22	U 1 2 9	1,000	T	D 8 0				
23	U 1 3 0	1,000	T	D 8 0				
2	U 1 3 1	1,000	T	D 8 0				
25	U 1 3 2	1,000	T	D 8 0				
26	U 1 3 3	1,000	T	D 8 0				

CONTINUE ON REVERSE

	EPA I.D. NUMBER (enter from page 1)		FOR OFFICIAL USE ONLY			
W M	I D 9 8 0 5 6 8 7 1 1 · 1		W	DUP	2 DUP	

IV. DESCRIPTION OF HAZARDOUS WASTES (continued)

	A. EPA HAZARD. WASTE NO. (enter code)	B. ESTIMATED ANNUAL QUANTITY OF WASTE	C. UNIT OF MEA-SURE (enter code)	D. PROCESSES	
				1. PROCESS CODES (enter)	2. PROCESS DESCRIPTION (if a code is not entered in D(1))
1	U 1 3 4	1,000	T	D 8 0	
2	U 1 3 5	1,000	T	D 8 0	
3	U 1 3 6	1,000	T	D 8 0	
4	U 1 3 7	1,000	T	D 8 0	
5	U 1 3 8	1,000	T	D 8 0	
6	U 1 4 0	1,000	T	D 8 0	
7	U 1 4 1	1,000	T	D 8 0	
8	U 1 4 2	1,000	T	D 8 0	
9	U 1 4 3	1,000	T	D 8 0	
10	U 1 4 4	1,000	T	D 8 0	
11	U 1 4 5	1,000	T	D 8 0	
12	U 1 4 6	1,000	T	D 8 0	
13	U 1 4 7	1,000	T	D 8 0	
14	U 1 4 8	1,000	T	D 8 0	
15	U 1 4 9	1,000	T	D 8 0	
16	U 1 5 0	1,000	T	D 8 0	
17	U 1 5 1	1,000	T	D 8 0	
18	U 1 5 2	1,000	T	D 8 0	
19	U 1 5 3	1,000	T	D 8 0	
20	U 1 5 4	1,000	T	D 8 0	
21	U 1 5 5	1,000	T	D 8 0	
22	U 1 5 6	1,000	T	D 8 0	
23	U 1 5 7	1,000	T	D 8 0	
24	U 1 5 8	1,000	T	D 8 0	
25	U 1 5 9	1,000	T	D 8 0	
26	U 1 6 0	1,000	T	D 8 0	

CONTINUE ON REVERSE

EPA I.D. NUMBER (enter from page 1)		FOR OFFICIAL USE ONLY	
W M I D 9 8 0 5 6 8 7 1 1 · 1		W DUP │ 2 │ DUP	

IV. DESCRIPTION OF HAZARDOUS WASTES (continued)

(l)	A. EPA HAZARD. WASTE NO. (enter code)	B. ESTIMATED ANNUAL QUANTITY OF WASTE	C. UNIT OF MEA-SURE (enter code)	D. PROCESSES				
				1. PROCESS CODES (enter)				2. PROCESS DESCRIPTION (if a code is not entered in D(1))
1	U 1 6 1	1,000	T	D 8 0				
2	U 1 6 2	1,000	T	D 8 0				
3	U 1 6 3	1,000	T	D 8 0				
4	U 1 6 4	1,000	T	D 8 0				
5	U 1 6 5	1,000	T	D 8 0				
6	U 1 6 6	1,000	T	D 8 0				
7	U 1 6 7	1,000	T	D 8 0				
8	U 1 6 8	1,000	T	D 8 0				
9	U 1 6 9	1,000	T	D 8 0				
10	U 1 7 0	1,000	T	D 8 0				
11	U 1 7 1	1,000	T	D 8 0				
12	U 1 7 2	1,000	T	D 8 0				
13	U 1 7 3	1,000	T	D 8 0				
14	U 1 7 4	1,000	T	D 8 0				
15	U 1 7 6	1,000	T	D 8 0				
16	U 1 7 7	1,000	T	D 8 0				
17	U 1 7 8	1,000	T	D 8 0				
18	U 1 7 9	1,000	T	D 8 0				
19	U 1 8 0	1,000	T	D 8 0				
20	U 1 8 1	1,000	T	D 8 0				
21	U 1 8 2	1,000	T	D 8 0				
22	U 1 8 3	1,000	T	D 8 0				
23	U 1 8 4	1,000	T	D 8 0				
~	U 1 8 5	1,000	T	D 8 0				
25	U 1 8 6	1,000	T	D 8 0				
26	U 1 8 7	1,000	T	D 8 0				

CONTINUE ON REVERSE

EPA I.D. NUMBER (enter from page 1)		FOR OFFICIAL USE ONLY	
W M I D 9 8 0 5 6 8 7 1 1 · 1		W D U P	T/M C 2 D U P

IV. DESCRIPTION OF HAZARDOUS WASTES (continued)

L'	A. EPA HAZARD. WASTE NO (enter code)	B. ESTIMATED ANNUAL QUANTITY OF WASTE	C. UNIT OF MEASURE (enter code)	D. PROCESSES 1. PROCESS CODES (enter)				2. PROCESS DESCRIPTION (if a code is not entered in D(1))
1	U 1 8 8	1,000	T	D 8 0				
2	U 1 8 9	1,000	T	D 8 0				
3	U 1 9 0	1,000	T	D 8 0				
4	U 1 9 1	1,000	T	D 8 0				
5	U 1 9 2	1,000	T	D 8 0				
6	U 1 9 3	1,000	T	D 8 0				
7	U 1 9 4	1,000	T	D 8 0				
8	U 1 9 6	1,000	T	D 8 0				
9	U 1 9 7	1,000	T	D 8 0				
10	U 2 0 0	1,000	T	D 8 0				
11	U 2 0 1	1,000	T	D 8 0				
12	U 2 0 2	1,000	T	D 8 0				
13	U 2 0 3	1,000	T	D 8 0				
14	U 2 0 4	1,000	T	D 8 0				
15	U 2 0 5	1,000	T	D 8 0				
16	U 2 0 6	1,000	T	D 8 0				
17	U 2 0 7	1,000	T	D 8 0				
18	U 2 0 8	1,000	T	D 8 0				
19	U 2 0 9	1,000	T	D 8 0				
20	U 2 1 0	1,000	T	D 8 0				
21	U 2 1 1	1,000	T	D 8 0				
22	U 2 1 3	1,000	T	D 8 0				
23	U 2 1 4	1,000	T	D 8 0				
2'	J 2 1 5	1,000	T	D 8 0				
25	U 2 1 6	1,000	T	D 8 0				
26	U 2 1 7	1,000	T	D 8 0				

CONTINUE ON REVERSE

EPA I.D. NUMBER (enter from page 1)		FOR OFFICIAL USE ONLY	
W M I D 9 8 0 5 6 8 7 1 1 · 1		W	DUP		2	DUP

IV. DESCRIPTION OF HAZARDOUS WASTES (continued)

ɯ	A. EPA HAZARD. WASTE NO. (enter code)	B. ESTIMATED ANNUAL QUANTITY OF WASTE	C. UNIT OF MEA- SURE (enter code)	D. PROCESSES	
				1. PROCESS CODES (enter)	2. PROCESS DESCRIPTION (if a code is not entered in D(1))
1	U 2 1 8	1,000	T	D 8 0	
2	U 2 1 9	1,000	T	D 8 0	
3	U 2 2 0	1,000	T	D 8 0	
4	U 2 2 1	1,000	T	D 8 0	
5	U 2 2 2	1,000	T	D 8 0	
6	U 2 2 3	1,000	T	D 8 0	
7	U 2 2 5	1,000	T	D 8 0	
8	U 2 2 6	1,000	T	D 8 0	
9	U 2 2 7	1,000	T	D 8 0	
10	U 2 2 8	1,000	T	D 8 0	
11	U 2 3 4	1,000	T	D 8 0	
12	U 2 3 5	1,000	T	D 8 0	
13	U 2 3 6	1,000	T	D 8 0	
14	U 2 3 7	1,000	T	D 8 0	
15	U 2 3 8	1,000	T	D 8 0	
16	U 2 3 9	1,000	T	D 8 0	
17	U 2 4 0	1,000	T	D 8 0	
18	U 2 4 3	1,000	T	D 8 0	
19	U 2 4 4	1,000	T	D 8 0	
20	U 2 4 6	1,000	T	D 8 0	
21	U 2 4 7	1,000	T	D 8 0	
22	U 2 4 8	1,000	T	D 8 0	
23	U 2 4 9	1,000	T	D 8 0	
24	U 3 2 8	1,000	T	D 8 0	
25	U 3 5 3	1,000	T	D 8 0	
26	U 3 5 9	1,000	T	D 8 0	

CONTINUE ON REVERSE

	EPA I.D. NUMBER (enter from page 1)		FOR OFFICIAL USE ONLY		

W M I D 9 8 0 5 6 8 7 1 1 · 1 T/A/C 1

W   DUP   T/A/C 2 DUP

IV. DESCRIPTION OF HAZARDOUS WASTES (continued)

	A. EPA HAZARD. WASTE NO. (enter code)	B. ESTIMATED ANNUAL QUANTITY OF WASTE	C. UNIT OF MEASURE (enter code)	D. PROCESSES	
				1. PROCESS CODES (enter)	2. PROCESS DESCRIPTION (if a code is not entered in D(1))
1	0 0 1 U	1,000	T	D 8 0	
2	0 0 2 U	1,000	T	D 8 0	
3	0 0 3 U	1,000	T	D 8 0	
4	0 0 4 U	1,000	T	D 8 0	
5	0 0 5 U	1,000	T	D 8 0	
6	0 0 6 U	1,000	T	D 8 0	
7	0 0 7 U	1,000	T	D 8 0	
8	0 0 8 U	1,000	T	D 8 0	
9	0 0 9 U	1,000	T	D 8 0	
10	0 1 1 U	1,000	T	D 8 0	
11	0 1 2 U	1,000	T	D 8 0	
12	0 1 3 U	1,000	T	D 8 0	
13	0 1 4 U	1,000	T	D 8 0	
14	1 4 7 U	1,000	T	D 8 0	
15	1 4 8 U	1,000	T	D 8 0	
16	0 1 5 U	1,000	T	D 8 0	
17	0 1 6 U	1,000	T	D 8 0	
18	0 1 7 U	1,000	T	D 8 0	
19	0 2 0 U	1,000	T	D 8 0	
20	0 2 1 U	1,000	T	D 8 0	
21	0 2 2 U	1,000	T	D 8 0	
22	0 2 3 U	1,000	T	D 8 0	
23	0 2 4 U	1,000	T	D 8 0	
2	0 2 5 U	1,000	T	D 8 0	
25	0 2 7 U	1,000	T	D 8 0	
26	0 2 8 U	1,000	T	D 8 0	

CONTINUE ON REVERSE

EPA I.D. NUMBER (enter from page 1)		FOR OFFICIAL USE ONLY
W M I D 9 8 0 5 6 8 7 1 1 · 1	W	DUP	T/A C 2 DUP

IV. DESCRIPTION OF HAZARDOUS WASTES (continued)

	A. EPA HAZARD. WASTE NO (enter code)	B. ESTIMATED ANNUAL QUANTITY OF WASTE	C. UNIT OF MEASURE (enter code)	D. PROCESSES 1. PROCESS CODES (enter)	2. PROCESS DESCRIPTION (if a code is not entered in D(1))
1	1 5 2 U	1,000	T	D 8 0	
2	0 2 9 U	1,000	T	D 8 0	
3	0 3 0 U	1,000	T	D 8 0	
4	0 3 1 U	1,000	T	D 8 0	
5	0 3 2 U	1,000	T	D 8 0	
6	0 3 3 U	1,000	T	D 8 0	
7	0 3 4 U	1,000	T	D 8 0	
8	1 5 0 U	1,000	T	D 8 0	
9	0 3 6 U	1,000	T	D 8 0	
10	0 3 7 U	1,000	T	D 8 0	
11	0 3 8 U	1,000	T	D 8 0	
12	1 5 1 U	1,000	T	D 8 0	
13	0 4 0 U	1,000	T	D 8 0	
14	0 4 1 U	1,000	T	D 8 0	
15	0 4 2 U	1,000	T	D 8 0	
16	0 4 3 U	1,000	T	D 8 0	
17	0 4 4 U	1,000	T	D 8 0	
18	0 4 6 U	1,000	T	D 8 0	
19	0 4 7 U	1,000	T	D 8 0	
20	0 4 8 U	1,000	T	D 8 0	
21	0 4 9 U	1,000	T	D 8 0	
22	0 5 0 U	1,000	T	D 8 0	
23	0 5 1 U	1,000	T	D 8 0	
2	0 5 2 U	1,000	T	D 8 0	
25	0 5 4 U	1,000	T	D 8 0	
26	0 5 5 U	1,000	T	D 8 0	

CONTINUE ON REVERSE

EPA I.D. NUMBER (enter from page 1)		FOR OFFICIAL USE ONLY	

`W M I D 9 8 0 5 6 8 7 1 1 · 1`   `W`   DUP   `2` DUP

IV. DESCRIPTION OF HAZARDOUS WASTES (continued)

Iz	A. EPA HAZARD. WASTE NO. (enter code)	B. ESTIMATED ANNUAL QUANTITY OF WASTE	C. UNIT OF MEASURE (enter code)	D. PROCESSES 1. PROCESS CODES (enter)				2. PROCESS DESCRIPTION (if a code is not entered in D(1))
1	0 5 6 U	1,000	T	D 8 0				
2	0 5 7 U	1,000	T	D 8 0				
3	0 5 8 U	1,000	T	D 8 0				
4	0 5 9 U	1,000	T	D 8 0				
5	0 6 1 U	1,000	T	D 8 0				
6	0 6 3 U	1,000	T	D 8 0				
7	0 6 4 U	1,000	T	D 8 0				
8	0 6 5 U	1,000	T	D 8 0				
9	0 6 8 U	1,000	T	D 8 0				
10	0 7 0 U	1,000	T	D 8 0				
11	0 7 1 U	1,000	T	D 8 0				
12	0 7 2 U	1,000	T	D 8 0				
13	0 7 3 U	1,000	T	D 8 0				
14	0 7 4 U	1,000	T	D 8 0				
15	0 7 5 U	1,000	T	D 8 0				
16	0 7 6 U	1,000	T	D 8 0				
17	0 7 7 U	1,000	T	D 8 0				
18	0 7 8 U	1,000	T	D 8 0				
19	0 7 9 U	1,000	T	D 8 0				
20	0 8 0 U	1,000	T	D 8 0				
21	1 5 2 U	1,000	T	D 8 0				
22	0 8 2 U	1,000	T	D 8 0				
23	0 8 3 U	1,000	T	D 8 0				
2	7 8 6 U	1,000	T	D 8 0				
25	0 8 8 U	1,000	T	D 8 0				
26	0 8 9 U	1,000	T	D 8 0				

CONTINUE ON REVERSE

	EPA I.D. NUMBER (enter from page 1)					FOR OFFICIAL USE ONLY		
W M I D 9 8 0 5 6 8 7 1 1 · 1						W	DUP	T/A C 2 DUP

IV. DESCRIPTION OF HAZARDOUS WASTES (continued)

	A. EPA HAZARD. WASTE NO. (enter code)	B. ESTIMATED ANNUAL QUANTITY OF WASTE	C. UNIT OF MEASURE (enter code)	D. PROCESSES				
				1. PROCESS CODES (enter)				2. PROCESS DESCRIPTION (if a code is not entered in D(1))
1	0 9 0 U	1,000	T	D 8 0				
2	0 9 2 U	1,000	T	D 8 0				
3	0 9 3 U	1,000	T	D 8 0				
4	0 9 4 U	1,000	T	D 8 0				
5	0 9 5 U	1,000	T	D 8 0				
6	0 9 6 U	1,000	T	D 8 0				
7	0 9 7 U	1,000	T	D 8 0				
8	0 9 8 U	1,000	T	D 8 0				
9	0 9 9 U	1,000	T	D 8 0				
10	1 0 0 U	1,000	T	D 8 0				
11	1 0 1 U	1,000	T	D 8 0				
12	1 0 2 U	1,000	T	D 8 0				
13	1 0 3 U	1,000	T	D 8 0				
14	1 0 4 U	1,000	T	D 8 0				
15	1 0 6 U	1,000	T	D 8 0				
16	1 0 8 U	1,000	T	D 8 0				
17	1 1 0 U	1,000	T	D 8 0				
18	1 1 1 U	1,000	T	D 8 0				
19	1 1 2 U	1,000	T	D 8 0				
20	1 1 3 U	1,000	T	D 8 0				
21	1 1 4 U	1,000	T	D 8 0				
22	1 1 5 U	1,000	T	D 8 0				
23	1 1 6 U	1,000	T	D 8 0				
2	1 7 U	1,000	T	D 8 0				
25	1 1 8 U	1,000	T	D 8 0				
26	1 1 9 U	1,000	T	D 8 0				

CONTINUE ON REVERSE

NOTE: Photocopy this page before completing if you have more than 26 wastes to list.

	EPA I.D. NUMBER (enter from page 1)			FOR OFFICIAL USE ONLY	
W	M I D 9 8 0 5 6 8 7 1 1 . 1		W	DUP	2 DUP

IV. DESCRIPTION OF HAZARDOUS WASTES (continued)

	A. EPA HAZARD. WASTE NO (enter code)	B. ESTIMATED ANNUAL QUANTITY OF WASTE	C. UNIT OF MEASURE (enter code)	D. PROCESSES 1. PROCESS CODES (enter)	2. PROCESS DESCRIPTION (if a code is not entered in D(1))
1	1 2 0 U	1,000	T	D 8 0	
2	1 2 1 U	1,000	T	D 8 0	
3	1 2 2 U	1,000	T	D 8 0	
4	1 2 4 U	1,000	T	D 8 0	
5	1 2 7 U	1,000	T	D 8 0	
6	1 2 8 U	1,000	T	D 8 0	
7	1 2 9 U	1,000	T	D 8 0	
8	1 5 3 U	1,000	T	D 8 0	
9	1 3 1 U	1,000	T	D 8 0	
10	1 3 2 U	1,000	T	D 8 0	
11	1 3 4 U	1,000	T	D 8 0	
12	1 3 5 U	1,000	T	D 8 0	
13	1 3 6 U	1,000	T	D 8 0	
14	1 3 7 U	1,000	T	D 8 0	
15	1 3 8 U	1,000	T	D 8 0	
16	1 3 9 U	1,000	T	D 8 0	
17	1 4 0 U	1,000	T	D 8 0	
18	1 5 4 U	1,000	T	D 8 0	
19	1 4 1 U	1,000	T	D 8 0	
20	1 4 2 U	1,000	T	D 8 0	
21	1 4 3 U	1,000	T	D 8 0	
22	1 4 4 U	1,000	T	D 8 0	
23	1 5 5 U	1,000	T	D 8 0	
2	4 6 U	1,000	T	D 8 0	
25		1,000	T	D 8 0	
26		1,000	T	D 8 0	

CONTINUE ON REVERSE

IV. DESCRIPTION OF HAZARDOUS WASTES (continued)

E. USE THIS SPACE TO LIST ADDITIONAL PROCESS CODES FROM ITEM D(1) ON PAGE 3.

NONE

EPA I.D. NO. (enter from page 1)

| F | M | I | D | 9 | 8 | 0 | 5 | 6 | 8 | 7 | 1 | 1 | T/A C 6 |

V. FACILITY DRAWING

All existing facilities must include in the space provided on page 5 a scale drawing of the facility (see instructions for more detail).

VI. PHOTOGRAPHS

All existing facilities must include photographs (aerial or ground—level) that clearly delineate all existing structures; existing storage, treatment and disposal areas; and sites of future storage, treatment or disposal areas (see instructions for more detail).

VII. FACILITY GEOGRAPHIC LOCATION

LATITUDE (degrees, minutes, & seconds)	LONGITUDE (degrees, minutes, & seconds)
4 2 1 7 0 0 N	0 8 3 1 2 2 1 W

VIII. GENERAL INFORMATION

Attach each of the following as separate attachments to the application:

1. General facility description
2. Chemical & physical analysis
3. Waste analysis plan
4. Security procedures
5. Inspection schedule
6. Contingency plan
7. Preparedness/prevention
8. Traffic information
9. Location information
10. Training program
11. Closure/post-closure plans
12. Cost estimates
13. Liability mechanism
14. Financial assurance
15. Topographic map

IX. SUPPLEMENTAL INFORMATION

Attach for all applications:

1. Hydrogeological report
2. Environmental assessment
3. Environmental monitoring program
4. Engineering plans

Attach for operating license applications only:

1. For new facilities, construction certification
2. Capability certification/compliance schedule
3. Proof of other permits or licenses
4. Restrictive covenant (landfills only)

X. FACILITY SPECIFIC INFORMATION

Attach the required technical information for each of the following:

1. Containers
2. Tanks
3. Incineration or thermal treatment
4. Treatment
5. Surface impoundments
6. Waste piles
7. Landfills
8. Land treatment

3000 FEET

GATE

FUTURE LANDFILL AREA

770 FEET

2520 FEET

1530 FEET

NON-HAZARDOUS LANDFILL
ACTIVE AREA

71 A.

1270 FEET

910 FEET

HAZARDOUS LANDFILL
ACTIVE AREA

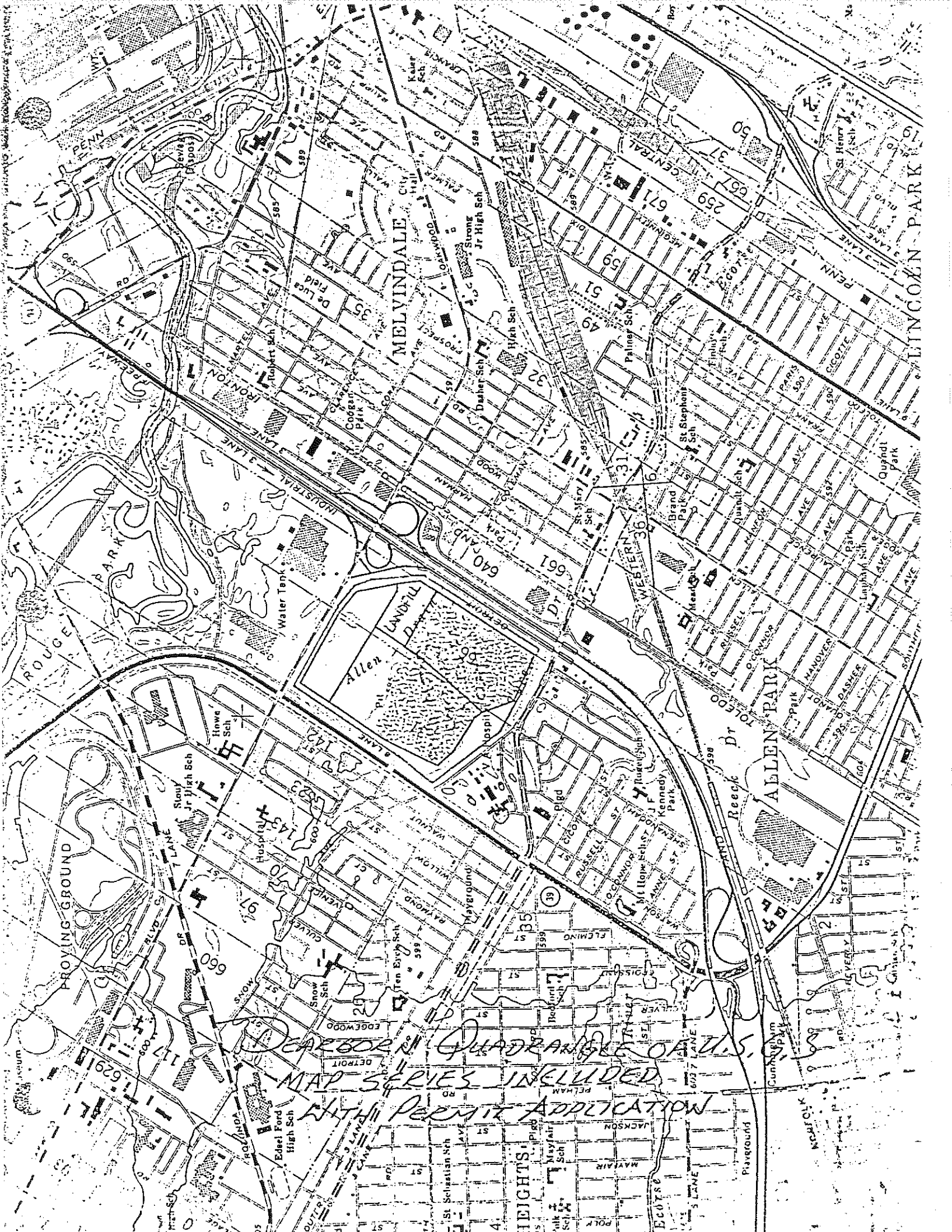27 A.

2400 FEET

56A.

PAST LANDFILL
AREA

1900 FEET

3850 FEET

1400 FEET

PERIMETER FENCE AND PROPERTY BOUNDARY

SCALE:
1 INCH = 400 FEET

DEARBORN QUADRANGLE - U.S. G
MAP SERIES INCLUDED
WITH PERMIT APPLICATION

B.1.6

(3)   The petition should include a copy of the
        air monitoring plan and the surface water
        drainage and sediment monitoring plan that
        will be implemented under the RCRA permit.
        These should include the background values
        that the monitoring results will be compared
        to. Also, the submittals should indicate
        what actions will be taken if background
        values are exceeded.

(4)   The petition should address in detail the
        elements of design and operation that will
        eliminate migration of hazardous
        constituents into air and surface water.
        Because the no-migration standard must also
        be met after post-closure, the discussion
        should also give consideration to worst-case
        events after the post-closure period that
        could expose hazardous constituents to the
        environment. For example, what elements of
        design and operation will ensure that
        long-term erosion of the final cover will
        not expose fine particulate waste to wind
        dispersal and precipitation runoff? What
        would prevent leachate accumulation from
        entering surface water drains after
        post-closure, assuming failure of the cover
        system? Some aspects of long-term
        prediction of landfill performance may be
        addressed through model simulation.

(5)   The petition should include a description of
        the final cover construction, and
        maintenance practices during post-closure.

(6)   The petition should include a discussion of
        potential future land-use changes, and
        changes to ground-water pumping locations
        and rates, that could result in a
        modification to the hydrologic regime
        beneath the facility. The long-term effect
        of such changes on the upward vertical
        hydraulic gradient may be addressed through
        model simulation.

(7)   The petition should address potential
      meteorological and climatic changes that
      could affect wear of the cap or leachability
      of the waste. The discussion should also
      address any solubilizing effect of acid
      rain.

     A quality assurance/quality control plan should accompany
any sampling, analysis, or modelling work undertaken in response
to the suggestions made in this letter.

     It should be remembered that no migration of hazardous
constituents "for as long as the waste remains hazardous" is a
very stringent standard. This is particularly true for toxic
metal constituents which will remain toxic indefinitely. In
order for EPA to consider granting a waiver pursuant to 40 CFR
268.6, your petition must provide an extensive demonstration
that Cell #2 will meet the no-migration standard.

     If we may be of further assistance, please call Amy Mills
of my staff at (202) 382-4422.

                         Sincerely,

                         Elizabeth Cotsworth

                         Elizabeth Cotsworth, Acting Chief
                         Assistance Branch

cc: Amy Mills
      Carol Witt, Region V ✔
      Ken Burda, MDNR

Date: **FEB 1 1 1988**

MEMORANDUM

Subject: Ford Allen Park Clay Mine Land Ban No-Migration Petition
         MID 980 568 711

From: Carol Witt, Geologist
         Region V, RPB, Michigan Section

To: Amy Mills, Geologist
         Headquarters, Assistance Branch

This memo is in response to your February 4, 1988 request for further
file information on the above referenced facility. Following identifies
the items which you requested, and the availability of the data.

1. Waste Analysis plan for all wastes to be placed in Master Cell 2.

   Attachment I is the Waste Analysis plan that will be incorporated
   into the draft permit. Also enclosed is a draft of conditions set
   under the Federal permit. Please be aware that the Michigan Department
   of Natural Resources (MDNR) is authorized to approve the plan,
   except for Land Ban conditions. The MDNR may also have some modifi-
   cations to the draft permit copy under Michigan Act 64 (MI Act 64).
   Mr. Pete Quackenbush of the MDNR, is the permit writer assigned to
   this site. Pete can be reached at (517) 373-2730, for further
   assistance.

2. Information concerning any past compliance problems with environmental
   significance.

   I have searched through the Federal compliance records. The only
   issue of some environmental significance occurred in 1986, when
   leachate levels in Cell 1 were in exceedance of the required six inches.
   The leachate was pumped out and the facility was brought back into
   compliance. There is no minimum technology type of leachate collection
   system in Cell 1. Mr. Larry AuBuchon of the MDNR district office,
   is the inspector for this site. He may be reached at (313) 459-9180,
   for further compliance assistance.

	TYP.	AUTH.	IL. CHIEF	IN. CHIEF	MI. CHIEF	MN/WI CHIEF	OH. CHIEF	TPS CHIEF	WMB CHIEF	WMD D/D
INIT. DATE										

3. A summary of interim status monitoring from the Part B.

   Attachment II provides you with all the interim status monitoring data
   from the Part A, this data includes the same information that is in
   the Part B, plus correspondance letters. I could not find an approval
   letter for the 265 monitoring waiver. There are no records in our
   enforcement files that a CME was completed for this site. The ground
   water certification was submitted, if you need a copy please let me know.

4. The approved ground water monitoring system in the draft permit.

   The MDNR is currently writing the conditions for the draft permit. The
   State is authorized for this portion of the program. We do not have a
   copy of their conditions yet. Please contact Mr. Terry McNeil of the
   MDNR, the geologist for this, at (517) 373-2730 for further assistance.

5. Information on landfill liner materials and installation procedures.

   Attachment III provides the Construction QA/QC Plan for Master Cell II.
   Ford has decided to create subcells in the main cell, so the final
   engineering plans are changing. As soon as I finish the draft permit
   conditions in the next two weeks, I will send you the complete design
   package.

6. Field data verifying artesian conditions in the underlying strata.

   I have no data in the files besides the Part B and Part A information
   I am sending you. The MDNR may have data in their files. Either
   Pete or Terry would be able to help you on that. Ford may have some
   data that our files don't include. You may want to contact them to
   have it ready when you visit the site.

7. Information on surface drainage from the facility.

   Attachment provides the Surface Water Environmental Monitoring Program
   Waste Management Unit Certification from Rouge
   Steel, and Corrective Information from the Part B. These items
   should help you in identifying pathways.

8. Information on airborne particulate control.

   Attachment IV provides the Air Environmental Monitoring Program. Clean
   water is used for dust suppression at the site.

9. Any other information from the permit or compliance files that you
   believe would be pertinent to making a determination on this petition.

   Attachment V includes the last Part B Notice of Deficiency letter from
   the MDNR, and the response letter from Rouge Steel. Also enclosed is
   the Facility Description from the Part B.

We are expecting to public notice the draft RCRA permit by the end of March. I will make sure that you get a copy at that time. If you need any further assistance please feel free to call me at FTS 886-6146.

cc: Rich Traub, REB
    Elizabeth Cotsworth, Hdqs.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

FEB 4 1988

OFFICE OF
SOLID WASTE AND EMERGENCY RESPONSE

MEMORANDUM

SUBJECT: Ford Allen Park Clay Mine No-Migration Petition

FROM: Amy Mills, Geologist
Assistance Branch (WH-563)

TO: Richard Traub, Chief
Michigan Section
EPA Region V

As we discussed, Headquarters has received a no-migration petition from the subject facility. I have been delegated responsibility for preparing a response for the Assistant Administrator. In reviewing the petition, I have identified several areas where additional information from the Region's permitting and compliance files on this facility would be helpful. I have supplied a copy of the petition to Carol Witt of your staff, and discussed some of the information gaps with her. She has agreed to send me copies of the following items from the Region's files:

o Waste analysis plan for all wastes to be placed in Cell #2.

o Information concerning any past compliance problems with environmental significance.

o A summary of interim status monitoring from the Part B.

o The approved ground water monitoring system in the draft permit.

I would also appreciate copies of:

o Information on landfill liner materials and installation procedures.

o   Field data verifying artesian conditions in the
    underlying strata.

o   Information on surface drainage from the facility (i.e.,
    surface water exposure routes).

o   Information on airborne particulate control (i.e., air
    exposure routes).

o   Any other information from the permit or compliance files
    that you believe would be pertinent to making a
    determination on this petition.

To the extent that these materials are used in making the
determination on this petition, they will become part of the
Agency's docket supporting the Federal Register notice.

Thank you for your cooperation. I plan to communicate
frequently with Carol Witt during the course of the petition
review, and I welcome any input either of you may have.

cc: Elizabeth Cotsworth
     Carol Witt, Region V

Ford Motor Company

3001 Miller Road
Dearborn, Michigan 48121

December 18, 1987

Mr. Lee Thomas, Administrator
U.S. Environmental Protection Agency
Headquarters
401 M Street
Southwest Washington D. C.
            20460

Subject: Petition for Exemption (Land Ban-K061)
          Ford Allen Park Clay Mine Landfill
          MID #980 568 711

Ford Motor Company hereby submits a petition, pursuant to 40 CFR
268.6, seeking an exemption from a prohibition for disposal of a
restricted hazardous waste, specifically K061 - Electric Arc
Furnace Baghouse Dust, in the Cell II unit located at the Ford
Allen Park Clay Mine Landfill. We believe the unique
hydrogeological conditions at the site demonstrate to a
reasonable degree of certainty that there will be no migration
from the disposal unit by the hazardous waste or it's hazardous
constituents.

Please review this petition and provide your comments to this
office at your earliest convenience. Should you have any
questions, please call Mr. David Miller at (313) 322-0700.

                    Yours truly,

                    Douglas A. Painter, Manager
                    Mining Department

Encl.

cc: Suzanne Rudsinski-E.P.A.
    Stephen Weil-E.P.A.

COPY 2

PETITION FOR EXEMPTION

FORD ALLEN PARK CLAY MINE LANDFILL
MID #980 568 711
December 18, 1987

TABLE OF CONTENTS

SECTION

Cell II is bounded on three sides by non-hazardous disposal cells and the fourth side is adjacent to the hazardous waste disposal Cell I. Cell I utilizes the natural insitu clay deposit coupled with the upward hydraulic gradient of the artesian bedrock aquifer as its liner system. The Engineering Drawings dated June 12, 1987 provided in this Section depict the relationship of the unit to the surrounding environment.

Ford Motor Company

Allen Park Clay Mine Landfill

E.P.A. I.D. No. MID 980568711

Demonstration for Exemption of Subpart F Requirements
Under 40 CFR 264.90 (b) (4)

Demonstration is hereby made to waive certain groundwater monitoring requirements
as provided for under 40 CFR 264.90 (b) (4) of the RCRA rules, based on the favor-
able site geology to the aforementioned rules. Specifically, the requested ex-
emption includes all sampling of the artesian aquifer immediately below the in-
situ saturated clay liner.

Site Description

Depositional Environment:

The site hydrology is governed by the last glacial period in which the Huron-
Erie ice lobe occupied southeast Michigan as shown on Exhibit A. When the ice
lobe retreated, a proglacial lake (Lake Maumee) formed, as shown on Exhibits B
and C. The site vicinity is located at least 16 miles from the shores of this
lake. The clay sediments deposited in the site vicinity reflect this low energy
depositional environment. The lacustrine clay is generally 80-120 feet in thick-
ness and has become an effective aquiclude since the recession of the lake. The
recharge area for the underlying aquifer is the moraine and outwash complex to
the northwest and the underlying Devonian carbonate formations.

Artesian Aquifer:

The confined aquifer is located approximately 70 feet below the existing grade
at the Allen Park site and varies in thickness from one to six feet. It exerts
an upward hydrostatic pressure on the clay aquiclude equivalent to 80 feet of head.
This hydraulic gradient in the upward direction is a counteracting force against
those of leachate migration (drag coupling effect and chemico-osmotic diffusion).
Under these conditions, there is no potential for migration of liquid from the
regulated unit to the uppermost aquifer during the active life of the regulated
unit and the post-closure care period. Refer to Exhibit D for a full discussion
on leachate migration at the facility.

Subsurface Soil Conditions:

The uniformity of the clay sediments in the Detroit area (Erie-St. Clair Plain)
has been documented by the numerous soils exploration and foundation engineering
studies required for all of the building and construction projects in the vicinity.

To be site specific, the following documentation has been established:

1) Clay mining operations, excavating clay for the manufacture of cement, have
    encountered more than 45 feet of uniform material over the entire site.

2) Seismic work on the cell bottom indicates that the bedrock is between 57 and
    70 feet below the cell bottom with uniform material to that depth. Refer
    to Exhibit E.

3) Soil samples taken from the five most recent borings indicate the clays are saturated to the surface from the artesian aquifer. Refer to Exhibit F.

4) Soil tests performed (grain size analysis, atterberg limits and permeability) on the clay provided more than adequate uniformity. Refer to Exhibit G.

5) The 12 deep borings indicate uniform soil conditions. Refer to Exhibit H.

6) The deep monitor wells into the artesian aquifer provide piezometric surface elevations that are consistent with the regional data which conclude that ground surface is below the piezometric surface. Refer to Exhibit H.

7) Additional studies, maps, and tests relating to subsurface conditions at the site indicate that subsurface clay is in excess of 25 feet thick with a permeability coefficient which is no greater than 6.0×10^{-8} cm/sec. In addition, the underlying artesian aquifer exerts hydrostatic pressure in an upward direction which precludes the possibility of leakage from the cell into the liner during the active life of the disposal facility. Refer to Exhibit H.

8) Additional geological information is provided by W. H. Sherzer, "Geological Report on Wayne County", Publication 17, Geological Series 9, 1913.

Summary:

Under the conditions stated in this demonstration, there is no potential for migration of liquid from the regulated unit to the uppermost aquifer during the active life of the regulated unit and the post-closure care period. The monitoring of water quality in the artesian aquifer cannot possibly detect leachate migration from the overlying disposal site. Accordingly, it is therefore believed that the Allen Park Clay Mine Landfill qualifies for the groundwater monitoring waiver set forth under the applicable regulations.

Prepared by: David S. Miller, Geologist
Mining Properties Department
Rouge Steel Company
(University of Michigan B.S. 1977)
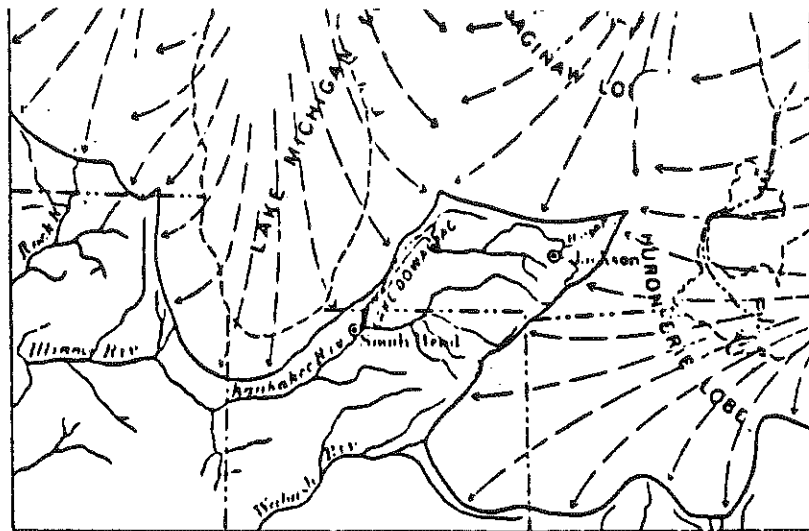
EXHIBIT A   (Map from Frank Leverett)
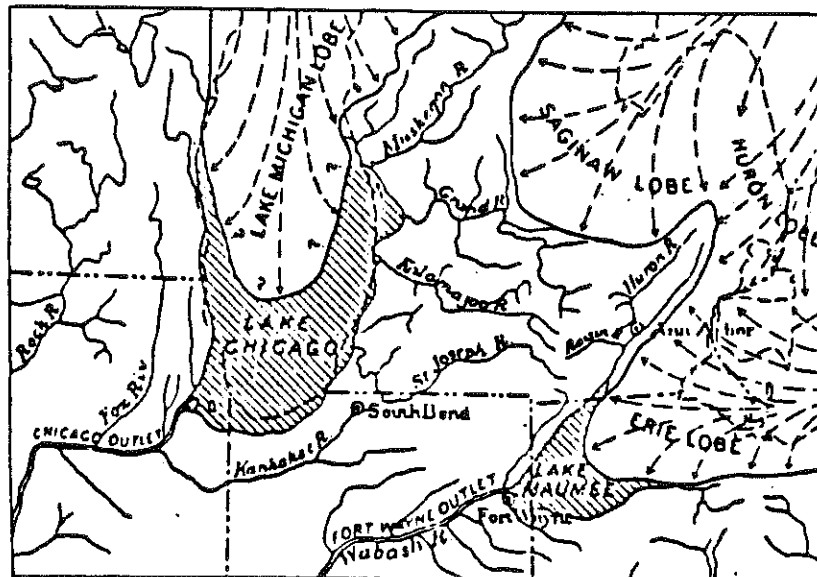

EXHIBIT B   (Map from Frank Leverett)
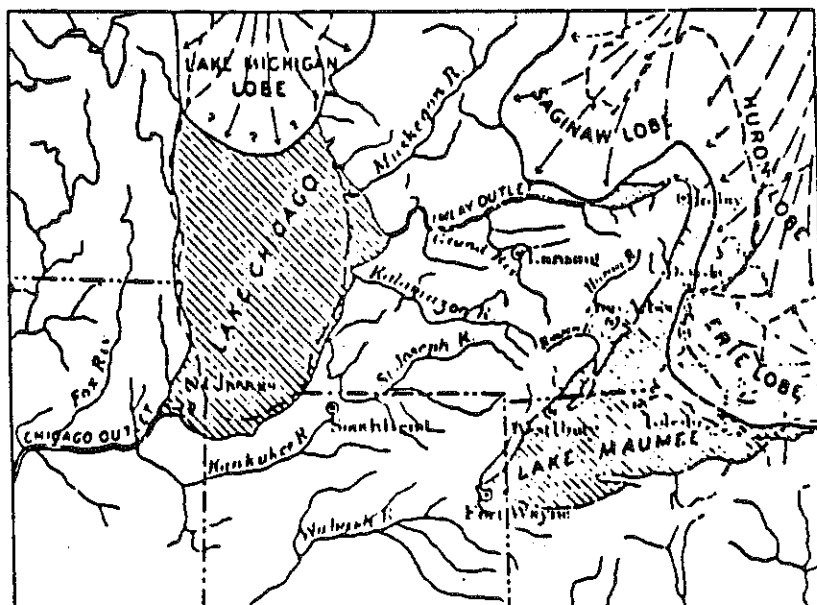

EXHIBIT C   (Map from Frank Leverett)

Report Prepared for:

Wayne Disposal, Inc.

CONTAINMENT INTEGRITY OF ALLEN PARK
CLAY MINE/LANDFILL

by

Donald H. Gray
Professor of Civil Engineering
The University of Michigan

Ann Arbor, Michigan

July 1983

SUMMARY

The possibility of leachate migration downward from the Allen Park Clay Mine/Landfill and contamination of an aquifer beneath were evaluated.

Analyses show that density differences between the leach-ate and groundwater will not cause a downward migration nor will they lead to a diffusion efflux from the site. A thick, uniform layer of silty clay beneath the site coupled with an upward hydraulic gradient effectively precludes the latter.

Comparison with results of salt water intrusion studies across clay aquitards having similar properties as the clay beneath the Allen Park site show that the solute (salt) will take at least 800 years to migrate across a clay barrier 30 feet thick under chemico-osmotic diffusion alone. A counter (or upward) hydraulic gradient will lengthen this breakthrough time even further.

There are insufficient amounts of organic compounds in the waste to affect the permeability of the clay. The proba-bility of accelerated leachate migration through the underly-ing clay is not supported by the composition of the wastes and the nature of the clay nor by the findings of leachate permeability studies reported in the technical literature.

Under these circumstances any observed increases in contaminant levels of monitor wells in the aquifer underlying the site could more reasonably come from sources laterally upgradient from the site rather than the clay mine/landfill above the site.

TABLE OF CONTENTS

CONTAINMENT INTEGRITY OF ALLEN PARK CLAY MINE/LANDFILL

I. INTRODUCTION

The Ford Motor Company who operate the Allen Park Clay Mine/Landfill have recently petitioned to discontinue ground water monitoring of an aquifer located approximately 70 feet below existing grade at the site. The landfill is underlain by dense, lacustrine clay which behaves as an aquiclude or aquitard. At least 25 feet or more of residual clay thickness separates the bottom of the landfill from the underlying aquifer. The aquifer is under artesian pressure and exerts an _upward_ hydrostatic pressure on the base of the clay aquitard equivalent to 80 feet of head. A general cross section or profile illustating these soil and hydrologic conditions at the site is shown in Figure 1.

Applicant maintains in his petition for discontinuance (EPA I.D. No. MIT 980568711) that monitoring is not necessary at the site because of a) the dense, uniform clay underlying the site which has a hydraulic permeability no greater than 6×10^{-8} cm/sec and b) the artesian pressure in the underlying aquifer which results in an upward hydraulic gradient across the overlying clay aquitard. Applicant claims that these site conditions will preclude the possibility of leachate migrating downwards out of the landfill and eventually contaminating the aquifer.

In response to this petition, the Wayne County Department of Public Health has raised several questions and concerns (letter form R.N. Ratz, Public Health Engineer, to B. Trethewey, Mining Properties Department, Ford Motor Company, 28 April 1983). The following concerns were raised in the letter:

1. The petition/report fails to address the possibility of leachate migrating down due to differences in densities of the leachate and groundwater.

2. The petition/report does not indicate if there are any organic constituents in the leachate that may increase the clay's permeability and permit downward movement.

The purpose of the present report is to respond to the above stated concerns. Additional information about the geo-hydrology of the site, about past containment/migration studies, and about the likely nature of the leachate and its effect on clay permeability are evaluated herein to determine the danger of landfill leachate migrating downwards from the site and reaching the underlying aquifer.

Elevation
USGS Datum

Feet NW
850

SE Feet
850

← Ground Water
Recharge Area
to Northwest

← Ground Surface

750

750

Artesian
Aquifer

Confining Stratum

Landfill
Site

Piezometric
Surface

650

650

Clay Aquiclude

550

Bedrock

550

450

450
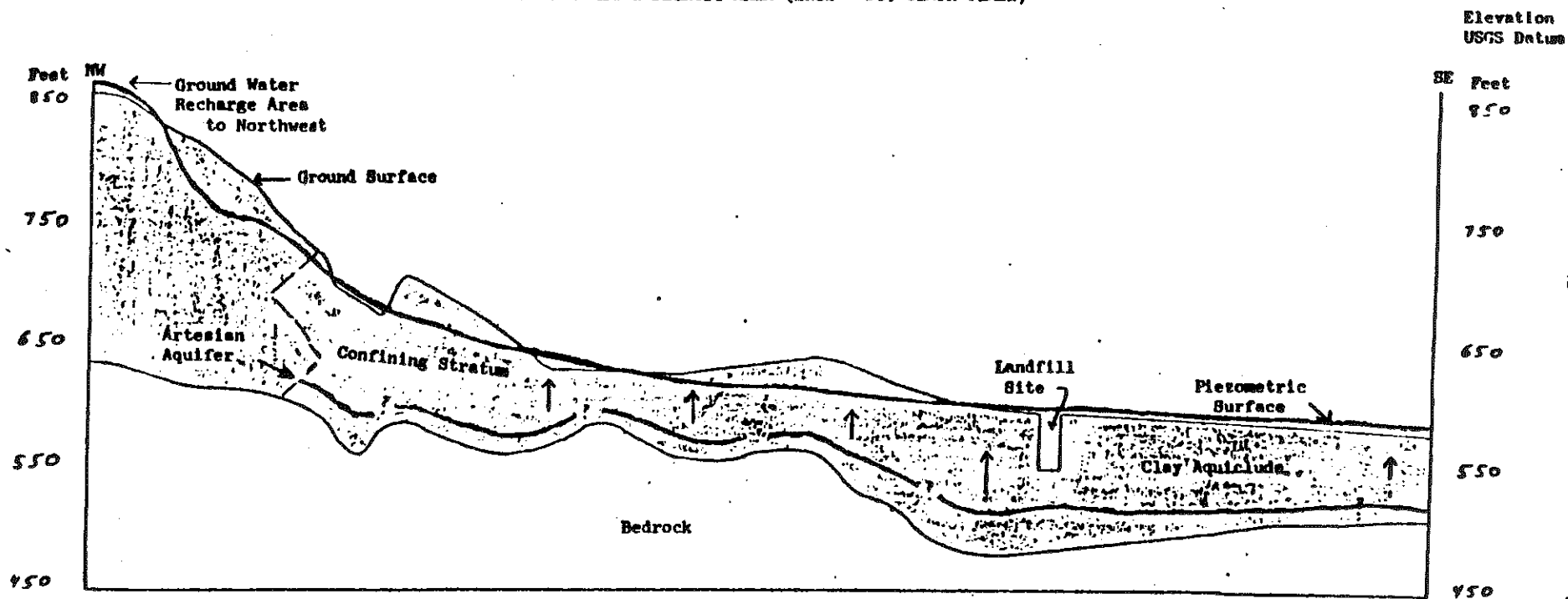
SCALE

Vertical 1"   = 100 Feet
Horizontal 1" = 2 Miles

Reference Map

USGS - Mich. Detroit District
Geology by W. H. Sherzer

Figure 1. Generalized cross-section through Allen Park Clay Mine/Landfill
showing soil and hydrologic conditions.

II. THE INFLUENCE OF PERMEANT DENSITY ON LEACHATE MIGRATION ACROSS CLAY BARRIERS

A. GENERAL

Permeant density plays a direct and indirect role in flow phenomena in porous media. Permeant density can affect solvent or solution flow rates via its influence on hydraulic conductivity. This influence can be calculated and shown to be minor or insignificant compared to the more likely and important influence of permeant density on solute diffusion.

A newly introduced permeant with a high concentration of dissolved material (e.g., a leachate) will also have a higher density. This high concentration in turn will cause the solute to diffuse through a porous medium to regions of lower concentration. It is this manifestation or aspect of a density increase in the permeant that requires careful scrutiny and analysis. In other words, the role and influence of permeant density are more important to solute diffusion under concentration gradients as opposed to solvent (or solution) convection under hydraulic gradients.

The analyses that follow are offered in support of these claims.

B. INFLUENCE OF PERMEANT DENSITY INCREASE ON HYDRAULIC PERMEABILITY

Both the viscosity and unit weight of a permeant can influence the permeability of a soil to a particular permeant. The hydraulic conductivity is defined in this case as a flow velocity under a unit hydraulic gradient (the usual practice in civil engineering). The influence of permeant density and viscosity can be ascertained explicitly by defining another permeability, i.e., the "intrinsic" or "absolute" permeability

$$K = \frac{k \, \mu}{\gamma} \qquad (1)$$

where: k = hydraulic conductivity, cm/sec
K = intrinsic or absolute permeability, cm^2
γ = permeant density or unit weight, dynes/cm^3
μ = permeant viscosity, poise

The intrinsic permeability(K) is a property only of the solids or matrix through which the permeant passes. Accordingly, for a particular soil (i.e., given grain size distribution and soil structure) and in the absence of permeant-soil reactions, K should be a constant. The influence of a variation in viscosity and density of the permeant on the hydraulic conductivity can be determined from this fact and from a relationship derived from Equation 1, viz.,

$$k_2 = k_1 (\gamma_2/\gamma_1) (\mu_1/\mu_2) \qquad (2)$$

where: subscript 1 - initial conditions (grnd water)
subscript 2 - final conditions (leachate)

An increase in density of the permeant will apparently cause a higher permeability. But, this same increase in density can also result in an increase in viscosity which will reduce the permeability. Both influences together will tend to offset one another, and it is unlikely that a density increase in the permeant (leachate) will significantly affect hydraulic conductivity. Furthermore, even if viscous retardation is discounted, density increases are highly unlikely to significantly increase permeability in actual practice as the following example will show.

Assume the ground above an aquitard or clay barrier is flooded with a fairly concentrated brine solution, namely sea water. The density of sea water (with a TDS of 36,000 ppm) is 1.036 gm/cc at 4° C vs. the density of the present interstitial water (with an average TDS of 1550 ppm) which is 1.002 gm/cc. This leads to a density ratio of 1.034 which is equivalent to only a 3.4 per cent increase in hydraulic conductivity (discounting viscous retardation). Therefore, density has little effect on hydraulic conductivity despite the almost.20 fold increase in dissolved solids concentration. It is the influence of the latter change, i.e., the increase in dissolved solids concentration, that requires careful analysis in evaluating the effectiveness of a clay barrier in containing leachate migration in this case.

C. INFLUENCE OF PERMEANT DENSITY INCREASE ON SOLUTE DIFFUSION

1. Background

Dissolved solids or solutes in a permeant can be transported through soils under both hydraulic and concentration gradients. The former is referred to as "drag coupling" and the latter as "chemico-osmotic diffusion." Both types of movement should be considered when evaluating the effectiveness of a clay barrier for preventing leachate migration.

Chemico-osmotic effects in fine grained soils have been examined in some detail by Olsen (1969) and Mitchell et al.(1973). The importance of chemico-osmotic diffusion increases in fine grained soils wilth low hydraulic conductivities. Studies commissioned by the State of California(1971) on salt intrusion problems in aquifer-aquitard systems have shown that as aquitards become clay rich and their permeabilities fall to levels on the order of .002 gpd/ft^2 or 10^{-7} cm/sec, the migration of solutes will be controlled by chemico-osmotic diffusion.

2. Flow of Solute under Combined Hydr. and Chem. Gradients

Equations can be derived which describe the flows of solute and solution in the pores of a sediment. The derivation of these equations and assumptions on which they are based are given by Mitchell et al.(1973). The one-dimensional, vertical, steady state flux of solute across a clay aquitard under a combined salt concentration(chemical) gradient and hydraulic gradient is given by the following relationship:

$$J_s = [(\chi_w/TR)c_s k_{ch} + c_s k_h] \, \partial h/\partial z + [D + c_s k_{ch}] \, \partial c_s/\partial z \qquad (3)$$

where: J_s = salt flux across an aquitard, moles/sec/cm^2
$\partial h/\partial z$ = hydraulic gradient (dimensionless)
$\partial c_s/\partial z$ = solute concentration gradient, moles/cm^4
D = diffusion constant, cm^2/sec
R = gas constant, ergs/mole/°K
χ_w = density of water, dynes/cc
T = absolute temperature, °K
c_s = average salt concentration, moles/cc
k_h = hydraulic conductivity, cm/sec
k_{ch} = chemico-osmotic coupling coefficient, cm^5/mole/sec

Relative contributions to the salt or solute flux can be calculated from Equation 3. Movement of solute can occur by diffusion whether a hydraulic gradient is present or not. A superposed hydraulic gradient may retard or accelerate movement of solute depending on:

a) Relative magnitude and direction of the hydraulic and solute concentration gradients.

b) Values of the hydraulic conductivity and chemico-osmotic coupling coefficient.

Equation 3 only yields the steady state flux of solute under combined hydraulic and chemical gradients. Equations can also be derived that give the initial or time dependent solute fluxes and the time required for "breakthrough" or first appearance of increased solute concentration on the downstream side of the aquitard. This initial, non-steady state process is quite complicated. Examples have been worked out for aquitards of different thicknesses and composition by Mitchell et al.(1973).

One of the most important findings of these studies on salt flux across clay aquitards was the importance of aquitard thickness on breakthrough time. Because the initial movement is non-steady, the breakthrough time increases with the square of the thickness of the aquitard. Theoretical studies of salt water intrusion across aquitards (State of California, 1971) have shown that salt ions will

take up to 800 years to migrate across an aquitard 30 feet
thick under chemico-osmotic diffusion alone. If the thick-
ness is reduced to 10 feet, the breakthrough time decreases
to only 80 years. The presence of an hydraulic gradient
could either accelerate or retard this time depending on
the relative magnitude and direction of this gradient and
other factors cited previously (see Figure 3).

3. Likelihood of Solute Efflux Through Clay at Allen Park Site

Solutes will tend to migrate or diffuse downward from
the landfill along a concentration gradient. On the other
hand, this movement can be impeded or even arrested by
the upward hydraulic gradient as a result of artesian
pressure in the underlying aquifer. Static water levels
in monitor wells around the landfill show that the piezo-
metric surface is almost 10 feet above existing grade or
ground surface elevation at the site (see Table 1). The
net, steady state flux of solute, if any, can be deter-
mined under these conditions from the solute flow equation
cited previously (Equation 3).

It is also pertinent to examine the results of a
similar type of study commissioned by the State of
California (1971). The latter study was designed to
determine salt efflux rates and breakthrough times in an
aquitard-aquifer system in the coastal ground water
basin near Oxnard, California (see Figure 2). The
problem posed in the California study was basically the
same as the pre-sent one; namely, given a sudden
increase in dissolved solids or solute concentration
atop a clay barrier (or aquitard) how long before the
salt migrated downward and reached an underlying aquifer
and at what rates of efflux? The problem was compounded
in the California example as a result of drawdown of the
piezometric surface in the underlying aquifer which also
caused a downward hydraulic gradient.

The two aquitards are quite similar in their
important respects. Both are approximately the same
thickness, have the same initial dissolved solids concen-
tration, and are composed of clayey sediments with low
hydraulic conductivities. The salient charateristics
and parameters of these two aquitards are summarized
and compared in Table 2. The main difference appears
to be in their respective hydraulic conductivities--
the Allen Park clay is an order-of-magnitude lower.

A dissolved solids concentration equal to that of
sea water was assumed in the leachate overlying the Allen
Park clay. Sea water is a good "worst case" choice because
sodium ions have high diffusion mobilities and are not
preferentially adsorbed on clay exchange sites as heavy

TABLE 1. ALLEN PARK CLAY MINE

MONITOR WELL - WATER LEVEL READINGS

Well Number	Ground Elevation, Ft.	Well Elevation[1] USGS	Ground Water[2] Elevation 11-4-81	Δ	Ground Water[3] Elevation 5-29-81	Ground Water[3] Elevation 3-26-81
2	595.1	600.76	600.67	3.6	600.44	600.21
5	595.7	605.92	605.09	9.4	604.62	604.49
7	594.1	597.35	591.01	-3.1	593.23	594.14
10	593.4	603.03	601.81	8.4	601.93	601.56
W-101	593.9	601.47	601.21	7.3		
W-102	591.3	600.81	603.22[4]	11.9		
W-103	593.9	605.06	603.52	9.6		
W-104	594.1	603.82	603.81	9.6		
W-105	594.5	604.08	603.86	9.4		

$\Delta_{N} = 8.9$

(1) Well Elevation is recorded as top of standpipe.

(2) Data Recorded by Michigan Testing Engineers, Inc.

(3) Data obtained from Michigan Department of Natural Resources.

(4) Well extended temporarily to obtain water level.

TABLE 1

TABLE 2. COMPARISON OF AQUITARD PROPERTIES AND SITE PARAMETERS

AQUITARD PROPERTY OR SITE PARAMETER	OXNARD CALIFORNIA	ALLEN PARK MICHIGAN
Composition	clayey silt & silty clays	silty clay
Thickness, ft	30	25 - 35
Ave. Water Content, %	24	20
Ave. Liquid Limit, %	31	28
Ave. Hydraulic Conduct, cm/sec	1×10^{-7}	2.6×10^{-8}
Hydraulic Gradient	0.33 - 1.0 (downward)	2.7 (upward)
Initial (interstitial) Pore Water Solute Conc, ppm	1800	1550
Final Solute Conc, ppm	36,000	36,000 (assumed)
Chemico-Osmotic Coupling Coefficient, cm^5/mole/sec	6.2×10^{-4}	6.2×10^{-4}
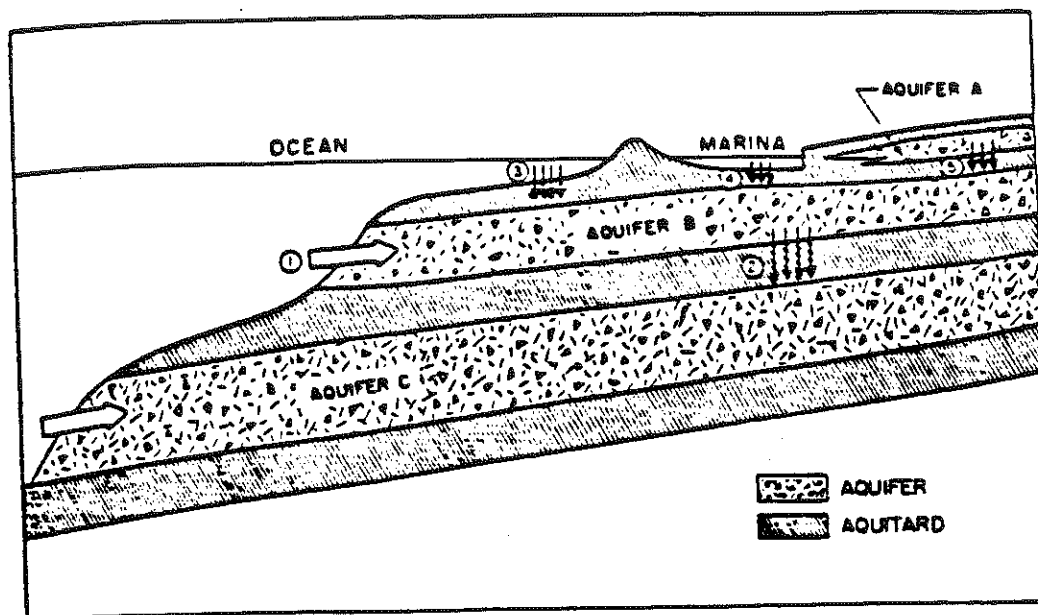
Figure 2. Generalized cross-section of multiple aquifer in a
coastal basin. Salt flux across aquitard can occur as
result of either salt water intrusion into aquifer (1,2)
or salt water entering directly above aquitard in shallow
coastal waters or marinas (3,4), or from salt contamina-
tion in near surface, perched aquifer (5).
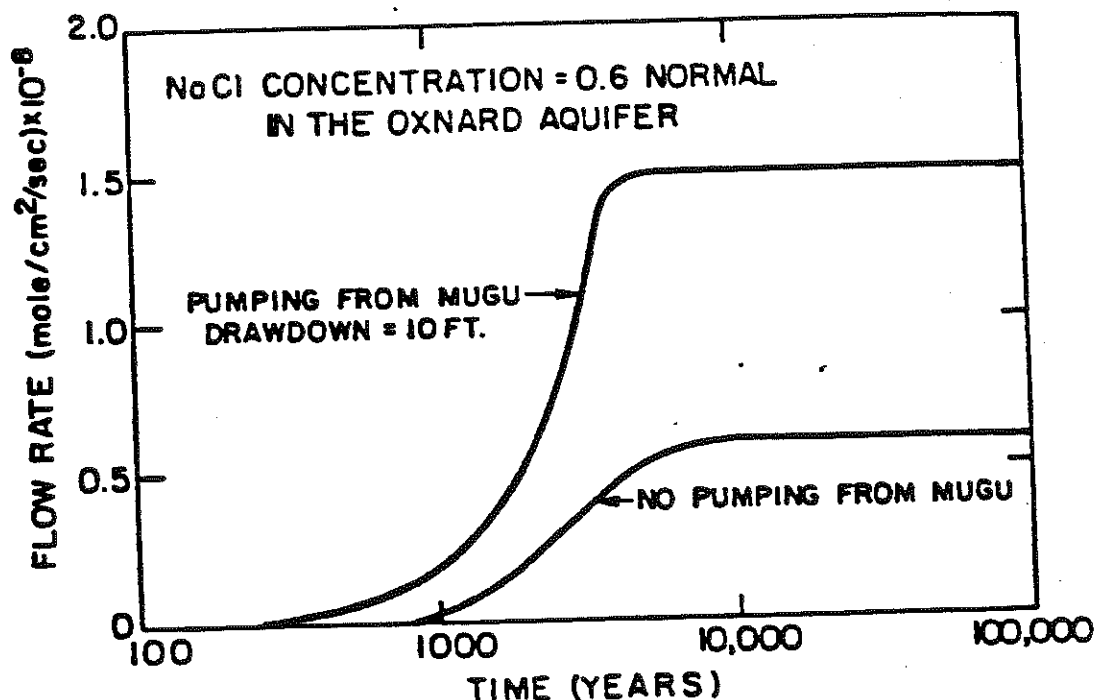
Figure 3. Solute efflux across aquitard into underlying aquifer as
a result of salt water intrusion in overlying aquifer.
Aquitard is 30 feet thick and has a hydraulic conducti-
vity of 10^{-7} cm/sec. Pumping from lower (Mugu) aquifer
superposes a 0.33 downward gradient on system.

metal ions would tend to be. The same chemico-osmotic coupling coefficient used in the California aquitard was also assumed applicable for the Allen Park clay. The value used is reasonable for the type of clay sediments present.

Results of the California study are presented in Figure 3 which shows the salt influx into the underlying aquifer as a function of time. Curves are presented for a no drawdown and 10-foot drawdown case (assuming the hydraulic gradient acts in the same direction as the salt concentration gradient). The horizontal portion of the two curves represents the steady state salt flux.

The main things to notice from this figure are the large breakthrough time (800 years) for the "no drawdown" case (i.e., in the absence of any hydraulic gradients) and the fact that in this aquitard the salt flux caused by drag coupling under a hydraulic gradient is larger. The steady state salt flux from the drag coupling under a combined 10-foot drawdown and salt concentration gradient is almost three times that from diffusion alone (no drawdown). Hence, in the event the hydraulic gradient was reversed, there would be no breakthrough and no downward salt flux provided the upward gradient exceeded about 0.2. In other words, under these conditions the two salt fluxes would be mutally opposed and exactly counterbalanced.

The relative contributions to steady state efflux in this example can be calculated with the aid of Equation 3. The following parameter values (taken from the study) were used in the calculation:

$$\partial h / \partial z \approx \Delta h / \Delta L = 10/30 = 0.33$$

$$\partial c / \partial z \approx (c_{s_2} - c_{s_1})/\Delta L = \frac{0.57 \times 10}{914} = 0.62 \times 10 \text{ moles/cm}^4$$

$$c_s = (c_{s_2} + c_{s_1})/2 = \frac{(0.60 - 0.03) \times 10}{2} = 0.32 \times 10 \text{ moles/cm}^3$$

$$D = 10^{-5} \text{ cm}^2/\text{sec}$$

$$R = 8.32 \times 10^7 \text{ ergs/mole/}^\circ K$$

$$T = 300 \text{ }^\circ K$$

$$\gamma_w = 10^3 \text{ dynes/cc}$$

$$k_h = 10^{-7} \text{ cm/sec}$$

$$k_{ch} = 6.2 \times 10^{-4} \text{ cm}^5/\text{mole/sec}$$

Using these values the calculated contributions to steady state solute flux are respectively:

This flux is greater than 3X the chemico-osmotic flux; and since it acts in the <u>opposite</u> direction, there will be no net downward flux of solute at the Allen Park site. The critical hydraulic gradient to maintain a zero net salt efflux is 0.8. This means that the groundwater table could rise to within 12 feet of present ground elevation (~595 ft) in the landfill and there would still be a sufficient upward hydraulic gradient (drag coupling effect) to completely counter solute efflux under chemico-osmotic diffusion (see summary below).

Position of Ground Water Table in the Landfill	Upward Hydraulic Gradient	Net, Steady State Solute Efflux Rate (moles/sec/ft^2)
At bottom	2.7	-1.51×10^{-8} (net influx)
12 feet from top	0.8	zero
At top	0.33	$+0.32 \times 10^{-8}$

These calculations are based on the existence of a static or piezometric head in the underlying aquifer approximately 9-10 feet above ground elevation (see Table 1).

Assumption of worst case conditions, namely, a rise in the groundwater table in the landfill to ground surface elevation, leads to a small, steady state efflux rate from chemico-osmotic diffusion. This occurs because the resulting hydraulic gradient (0.33) is no longer large enough to completely oppose the chemico-osmotic salt flux. The breakthrough times, however, would be so immense (1000's of years) that the steady state flux under these conditions is largely irrelevant.

It is important to note that the preceding calculations are also based on the following "worst case" assumptions:

1. A highly saline leachate with a concentration and composition equal to that of sea water.

2. No interaction between the solute and clay.

In actual practice, there would be some uptake and adsorption of solutes on the clay. This adsorption would attenuate or limit further solute concentrations in the leachate as it passed through the clay.

III. EFFECT OF LEACHATE CONSTITUENTS ON THE PERMEABILITY OF CLAY

A. GENERAL BACKGROUND

The possibility that leachate--either in the solvent or solute phase--might affect clay permeability and hence its containment integrity has been raised by a number of investigators (Anderson and Brown, 1981; Haxo, 1981; and Folkes, 1982). One of these studies has shown that <u>concentrated</u> organic liquids can increase clay permeability by several orders-of-magnitude (Anderson and Brown, 1981).

All of these studies were conducted in the laboratory with simulated leachates from particular types of wastes and under particular testing conditions. The danger of blindly applying these test results to a field situation have been noted recently by Gray and Stoll (1983). It is essential to ask the following before the results of these lab tests can be applied to a given field situation:

1. <u>What was the nature of the leachate in the lab tests?</u> What are the concentrations of various constituents in the leachate in the field as opposed to the lab tests? How relevant are the lab test results in the light of potentially large differences in leachate composition (lab vs. field)?

2. <u>How did the leachate contact or interact with the clay in the lab tests?</u> Was it forced through? If so, at what gradient? Is there any prospect that the leachate will be able to penetrate/permeate through the clay containment in the field in like manner? In other words are the necessary gradients and other conditions present to permit this to happen?

3. <u>What was the failure or clay degradation process by which the apparent permeability increase occured in the lab tests?</u> Was it by a) dissolution, b) syneresis, c) piping? Could these mechanisms reasonably occur in the field given the type, water content, and density of the in-situ clay plus the nature and concentration of organic and inorganic compounds in the leachate?

B. WASTE AND LEACHATE COMPOSITION AT THE ALLEN PARK CLAY MINE

The types, composition, and relative amounts of wastes placed in the Type II Solid Waste Landfill at Allen Park are shown in Tables 3 and 4. The results of typical E.P.T leachate tests on these wastes are shown in Table 5. The likely nature and composition of the landfill leachate can be estimated from this information. This estimate is adequate for purposes of evaluating the probable effect of the leachate on clay permeability.

TABLE 3. ALLEN PARK CLAY MINE - SOLID WASTE LANDFILL CONSTITUENTS

Fly Ash	-	50%
Blast Furnace Filter Cake	-	15%
Construction Debris - Sweepings - Clean-Up	-	14%
BOF Dust	-	6%
Foundry Sand	-	6%
Electric Furnace Dust	-	4.8%
Coal and Coke	-	3%
Coke Oven Decanter Tar Sludge	-	0.6%
Glass	-	0.5%
Wood Ash	-	0.5%
BOF Kish	-	0.3%
Wastewater Treatment Sludge	-	0.2%
Grinding Mud	-	0.1%

TABLE 4. ALLEN PARK CLAY MINE WASTES. TYPICAL AS RECEIVED ANALYSES (mg/kgm).

	Decanter Tank Tar Sludge	Electric Arc Furn. Dust	Blast Furn. Flue Dust	BOF Flue Dust	Blast Furn. Filter Cake	Foundry Sand	BOF Kish	Fly Ash	Lime Dust	Coke Breeze
EP Toxic	No	Yes(Zn,Pb,Cd)	No	No	No	No	No	Exempt	No	No
Iron	----	350,000	122,000	560,000	150,000	1,200	490,000	34,500	----	5,800
Carbon	----	4,700	520,000	7,400	404,000	6,600	240,000	194,000	----	950,000
Arsenic	----	50	19	42	2	20	78	----	----	15
Barium	----	<1	<1	<1	20	<1	<1	----	----	<1
Cadmium	----	95	<1	50	8	<1	<1	----	----	<1
Chromium	----	500	<1	130	70	<1	60	----	----	1
Lead	----	<4,500	<1	3,000	350	44	<1	----	----	69
Mercury	----	<1	<1	<1	<1	<1	<1	----	----	<1
Selenium	----	120	90	<1	<1	35	70	----	----	3
Silver	----	6	<1	<1	9	<1	<1	----	----	19
Manganese	----	39,000	7,500	10,000	4,500	79	2,800	----	----	70
Zinc	----	150,000	120	22,000	400	40	194	----	----	110
Phosphorus	----	450	200	190	300	400	170	----	----	90
Sulfur	----	3,600	4,000	1,600	4,000	200	350	3,100	----	7,300
Calcium	----	61,000	18,000	2,000	20,000	60	580	13,100	714,700	300
Magnesium	----	11,000	7,500	9,600	13,000	100	3,000	5,400	----	300
Aluminum	----	2,400	2,200	<2	3,700	<2	1,600	147,200	----	<2
Silicon	----	15,000	20,000	8,000	83,000	450,000	25,000	201,700	----	20,000
Potassium	----	5,900	980	5,000	2,200	170	640	9,700	----	220
Sodium	----	5,200	440	2,300	1,500	390	630	3,700	----	550
Fluorine	----	26	10	23	4	<1	48	----	----	<1
Cyanide	14	<1	<1	<1	3	<1	<1	----	----	2
Phenol	1,800	<1	<1	<1	3	<1	2	----	----	3
Naphthalene	2,700	----	----	----	----	----	----	----	----	----

-185-

TABLE 5. ALLEN PARK CLAY MINE SOLID WASTES
TYPICAL E.P.T. LEACHATE TEST RESULTS (Mg/l)

Parameter	Blast Furnace Flue Dust	BOF Flue Dust	Blast Furnace Filter Cake	Foundry Sand	BOF Kish	Coke Breeze	Wastewater Treatment Sludge
Arsenic	0.04	0.02	< 0.1	0.03	0.1	<0.1	.008
Barium	<0.8	<0.04	< 0.8	<0.08	< 0.8	<0.8	.45
Cadmium	0.01	0.03	< 0.08	<0.005	<0.005	<0.005	.005
Chromium	<0.1	<0.05	<0.05	<0.1	< 0.1	<0.1	.101
Lead	<0.2	1.7	1.7	<0.2	<0.2	<0.2	.025
Mercury	0.0007	< 0.01	< 0.2	<0.2	<0.2	<0.2	.0005
Selenium	1.0	<0.01	<0.2	0.10	0.4	<0.5	.003
Silver	< 0.1	<0.01	< 0.01	<0.1	<0.1	<0.1	.04

The data in Tables 3 and 4 indicate that 50 per cent of the solid waste consists of relatively inert fly ash and that some 89 per cent of the wastes consist of materials that do not contain significant amounts of heavy metals (Zn, Pb, Cd) or organics known or suspected to be toxic such phenol and naphthalene (see Table 4). The coke oven decanter tar sludge is a possible source of organics (phenol and napthalene), but this waste comprises only 0.6 per cent of the total stream in the Type II Solid Waste landfill.

C. PROBABILITY OF ORGANICS IN LEACHATE AFFECTING CLAY PERMEABILITY AT ALLEN PARK SITE

Anderson and Brown (1981) found that several organic liquids, viz., aniline, acetone, ethylene glycol, heptane, and xylene, cause large increases in permeability of four compacted clay soils. Pure organic liquids were used in their study. One of the authors (Anderson, 1982) later emphasized that their results cannot be used to support claims that clay liners permeated by dilute organic liquids may be susceptible to large permeability increases.

Haxo (1981) reported results of up to 52 months of liner exposure to selected industrial wastes. He included several organic wastes, namely, aromatic oil, Oil pond 104, and a pesticide. The results of large permeameter tests on a compacted fine-grained soil and admixed materials are summarized in Table 6. Although a small amount of seepage passed through the compacted, fine-grained soil liner, no permeability increases were reported with any of the organic wastes.

On the basis of these studies and with the caveats noted at the beginning of this section in mind, it is possible to evaluate the likely effect of the landfill leachate on clay permeability at the Allen Park site.

1. Type II Solid Waste Landfill

As noted previously the existing landfill contains small quantities of coke oven decanter tar sludge which is a possible source of organics (phenol and naphthalene), but this waste comprises only 0.6 per cent of the total. Phenol and naphthalene are present in the tar component of this waste in concentrations estimated by Desha (1946) of 0.1 and 2.2 per cent by weight respectively. Accordingly, the amount of phenol and naphthalene present in the total waste stream are .006 and .013 per cent by weight respectively. These amounts constitute a very low fraction and they suggest that leachate from the total waste stream will tend to have very low concentrations of phenol and napthalene. Therefore, the organics in the leachate from the Type II Solid Waste landfill are quite unlikely to affect clay permeability.

TABLE 6. EFFECTS OF INDUSTRIAL WASTES ON SOIL AND ADMIX LINERS
(from Haxo, 1981)

Liner material	Acidic waste (HNO₃, HF, HOAC)	Alkaline waste (spent caustic)	Lead (low lead gas washing)	Oily waste		Pesticide (weed killer)
				Aromatic oil	Oil pond 104	
Compacted fine-grained soil 305 mm thick	Not tested	Measurable rate of seepage $v_s = 10^{-10}-10^{-9}$ m/s, waste penetrated 3–5 cm after 30 months (a)		$k=1.8\times10^{-10}$ $k=2.4\times10^{-10}$ $k=2.6\times10^{-10}$ (tests on soil after 30 months)	†	†
Soil cement 100 mm thick	Not tested	No measurable seepage after 30 months				
Modified bentonite and sand (2 types) 127 mm thick	Not tested	Measurable seepage after 30 months, channelling of waste into bentonite (b)			Failed (waste seepage through liner)	‡
Hydraulic asphalt concrete 64 mm thick	Failed	Satisfactory	Waste stains below liner asphalt mushy	Not tested	Not tested	Satisfactory
Spray-on asphalt and fabric 8 mm thick	Not tested	Satisfactory	Waste stains below liner	Not tested	Not tested	Satisfactory

*From data presented by Haxo (1981).
†Same as (a).
‡Same as (b).

2. Type I Hazardous Waste Landfill

In the future the decanter tar sludge will be placed in a separate landfill that will be upgraded to accept hazardous wastes. This action will increase the relative proportion of organics (phenol and naphthalene) in the waste stream. Leachate tests run on pure samples of decanter tar sludge using a distilled water extraction procedure (Calspan, 1977) have produced phenol concentrations of approximately 500 ppm. Even this concentration is far removed from the very high concentrations of organic solvents used by Anderson and Brown (1981) in their permeability tests on different clays. Accordingly, organics in the leachate from the Type I Hazardous Waste landfill are also unlikely to affect clay permeability.

In summary: It does not appear likely nor reasonable that organics present in the wastes at the Allen Park Clay Mine/Land-fill will cause a permeability increase given their low concentration and the absence of any substantiation in the published technical literature for such an increase under these conditions.

IV. CONCLUSIONS

(1). There appears to be very little likelihood of leachate migrating downward from the Allen Park Clay Mine/Landfill and contaminating the aquifer beneath the clay.

(2). A density difference between the leachate and groundwater will have little or no influence on hydraulic permeability or downward migration nor will it lead to diffusion efflux of solutes. A thick, uniform bed of silty clay beneath the site coupled with an upward hydraulic gradient precludes the latter. Calculations and analyses are provided herein to support this finding.

(3). Comparison with results of salt water intrusion studies across clay aquitards having similar properties as the clay beneath the Allen Park Clay Mine site show that the solute (salt) will take at least 800 years to migrate across a clay barrier 30 feet thick under chemico-osmotic gradients alone. A counter (or upward) hydraulic gradient will increase this breakthrough time even more.

(4). The waste and its leachate are unlikely to increase the permeability of the underlying clay. This claim is reasonable in view of the low concentrations of organics in the total waste stream and in the light of the findings and caveats of permeability/exposure tests with organic permeants reported in the technical literature. This conclusion applies to both the existing Type II Solid Waste landfill and a proposed Type I Hazardous Waste landfill that will accept the coke oven decanter tar sludge.

(5). The composition of the waste and underlying clay do not suggest properties or combination of properties that could lead to a containment failure caused by such processes as piping, acid/base dissolution, or syneresis.

(6). Under these circumstances any observed increase in contaminant levels of monitor wells in the aquifer underlying the site could just as well come from other sources laterally upgradient from the site rather than from the clay mine/landfill above the site.

(7). These findings and conclusions support the basis of applicant's petition for discontinuing further monitoring of the wells penetrating the aquifer beneath the site.

V. REFERENCES CITED

Anderson, D. (1982). "Does landfill leachate make clay liners more permeable?" Civil Engineering-ASCE, Vol. 52, #9, 66-69

Anderson, D. and Brown, K.W. (1981). "Organic leachate effects on the permeability of clay liners," In Land Disposal: Hazardous Waste, Proceedings, 7th Annual Research Symposium, U.S. Envl. Protection Agency, Philadelphia, pp. 119-130

Calspan Corp (1977). "Assesment of industrial hazardous waste practices in the metal smelting and refining industry," v. 3, Appendices. EPA Contract No. 68-01-2604, April 1977

Desha, L. (1946). Organic Chemistry. McGraw-Hill Book Company, New York, NY

Folkes, D.J. (1982). "Control of contaminant migration by use of clay liners," Can. Geotech Journ. Vol. 19, pp. 320-344

Gray, D.H. and Stoll, U. (1983). "Leachates and liners," Civil Engineering-ASCE, (letter to editor), Vol. 53, No.1, p. 20

Haxo, H.E. (1981). "Durability of clay liners for hazardous waste disposal facilities," In Landfill Disposal: Hazardous Waste, Proceedings, 7th Annual Research Symposium, U.S. Envl. Protection Agency, Philadelphia, pp. 140-156

Mitchell, J.K., Greenberg, J.A., and Witherspoon, P.A. (1973). "Chemico-osmotic effects in fine-grained soils," ASCE Journ. of SMFD, Vol 91, No. SM4, pp. 307-321

Olsen, H. (1969). "Simultaneous fluxes of liquid and charge in saturated kaolinite," Soil Sci. Soc. of Amer. Proceedings, Vol. 33, No. 3

State of California (1971). "Aquitards Sea Water Intrusion in the Coastal Ground Water Basin of Oxnard Plain, Ventura County," Bulletin 63-4, State of California, Dept of Water Resources

1704 Morton Street
Ann Arbor, Michigan
48104

25 September 1983

Mr. Mark Young
Wayne Disposal Company
P.O. Box 5187
Dearborn, MI 48128

RE: Allen Park Clay Mine/Landfill

Dear Mark:

I recently wrote a computer program (*CLAYWALL*) that can be
used to calculate solute transport across a clay barrier under
combined diffusion and advection (hydraulic flow). The pro-
gram computes the exit/source concentration ratio (C/Co) as a
function of elapsed time (t) on the downstream side of a clay
wall or barrier of thickness (X).

The program was written with a clay slurry cut-off wall in mind,
but is general enough that it can be used with any clay layer
or barrier. The input parameters to the program are:

D_e = efffective diffusion coefficient, ft^2/yr
K   = hydraulic permeability, ft/yr
X   = thickness of wall or barrier, ft
P   = porosity
I   = hydraulic gradient...(+) if same direction,
       (-) if opposite direction to solute concen-
       tration gradient
t   = elapsed time, yrs

The program is based on the solution to the equation that des-
cribes one-dimensional solute transport in a saturated porous
medium under both hydraulic and solute concentration gradients.
This equation has the following form:

C/Co = 0.5[erfc((X-vt)/sqr(4DK)) + exp(vX/D) erfc((X+vt)/sqr(4DK))]

where: v = ave seepage velocity = (KI/P)

The solution assumes the following conditions:

1. Saturated, one-dimensional flow.

2. No reaction between solutes and porous medium. Chloride
   typically behaves this way.

3. Diffusion controlled, i.e., the pore water velocity is so low that mechanical mixing is negligible and the dispersion is equal to the effective diffusion coeffficient. (this condition is satisfied when K < 1.0E-07.

I ran the program using data for the silty clay layer underlying the Allen Park ClayMine/Landfill. The following values for the input data were used:
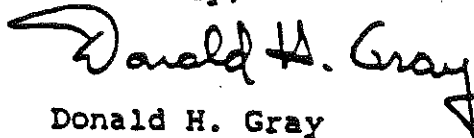
$$D = 0.102 \text{ ft}^2/\text{yr} \ (6.3E-06 \text{ cm}^2/\text{sec})$$
(published value for clay tills)
$$K = 0.025 \text{ ft/yr} \ (2.5E-08 \text{ cm/sec})$$
$$X = 30 \text{ ft}$$
$$P = 30 \%$$
$$I = -0.1, -0.3, \text{ and } -1.0$$

The results of the analysis are shown in the attached graph. At a counter hydraulic gradient of -0.3 the exit/source solute concentration ratio does not exceed 0.0001 until 700 years have elapsed. You may recall that a counter hydraulic gradient of -0.3 occurs when the leachate is allowed to rise in the landfill to the ground surface...a worst case scenario. For larger (negative) counter hydraulic gradients the ratios become even smaller. In fact for I < -0.5 (i.e., counter hydraulic gradients larger than 0.5) the ratio C/Co is less than 1.0E-05 at all elapsed times.

These results confirm the findings of my earlier report which were based largely on analogy to solute transport studies in clay aquitards. The present findings are based on analysis of actual soil and site parameters. Keep in mind, also, that the analysis is still quite conservative because it neglects possible adsorption (reaction) of solutes with the clay.

A copy of the computer program and typical output are enclosed. It is written in BASIC and is designed to be run on a personal computer. If you have any questions about the analysis, please feel free to contact me.

Sincerely,

Donald H. Gray
Professor of Civil Engineering

Encl

$D = 0.102$ ft^2/yr (3×10^{-6} cm^2/s)
$k = 0.025$ ft/yr (2.5×10^{-8} cm/s)
$n = 30\%$
$X = 30$ ft.

SOLUTE CONC – RATIO – C/C_o

Co

CLAY BARRI...
D, k, n

$-i$ $+i$

DIFFUSION   HYD. FLOW

X

C/C_o

$i = -0.1$

Note:
For $i \leq -0.5$
$C/C_o \leq .00001$
@ all times

$i = -0.3$

ELAPSED TIME – YRS

100   1000   10000
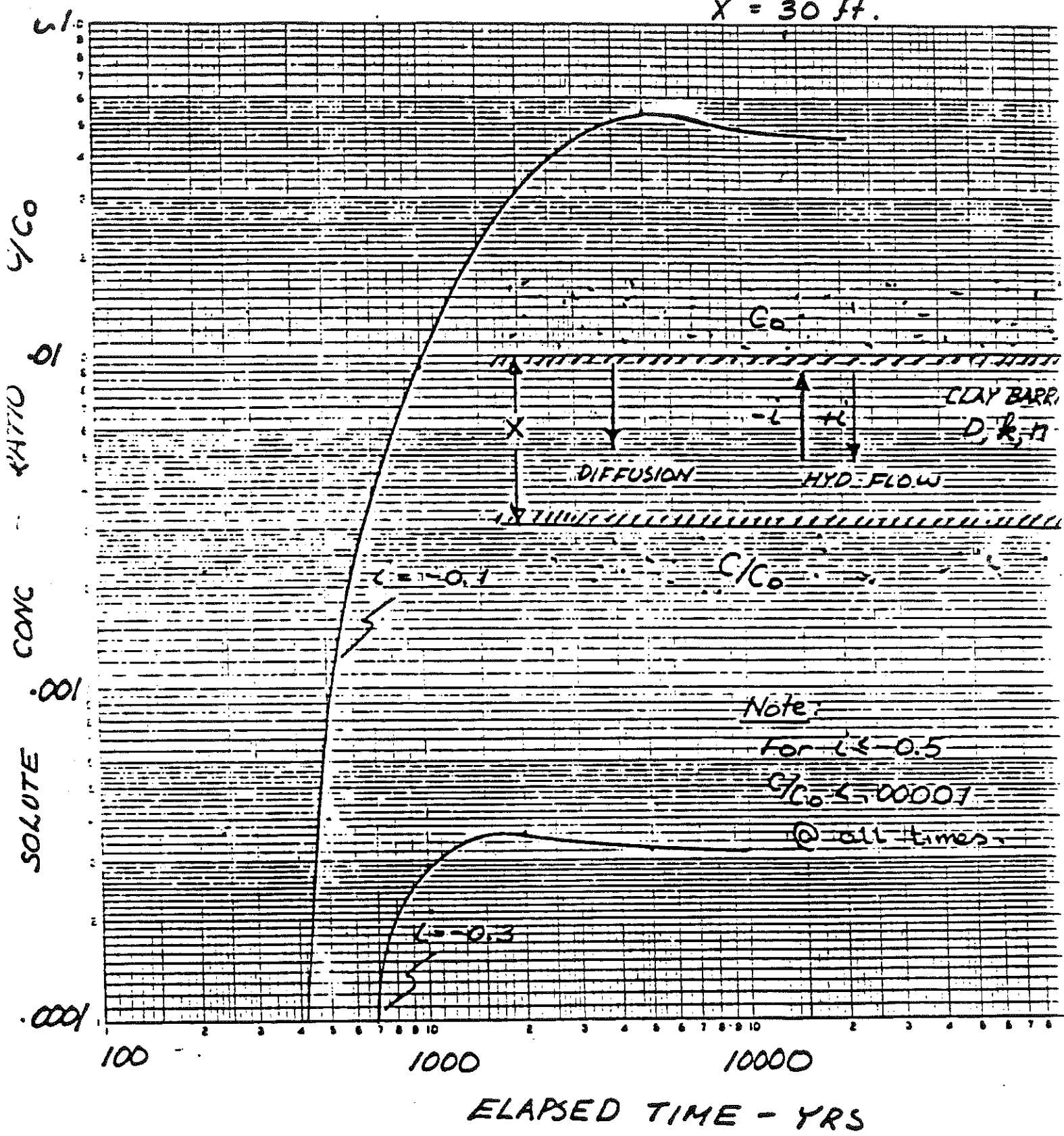
```
run
Porosity: 0.3
Permeability(ft/yr): .025
Diffusion Coef(ft /yr): 0.102
Wall Thickness: 30
Hydraulic Gradient: -0.3
Time(yrs): 500
-----------------------------------------------------------
1st Argument(Y1)is:                          2.9756
1st Error Function is:                        0.9999
2nd Argument(Y2)is:                           1.22525
2nd Error Function is:                        0.9173
Exit/Source Concentration Ratio  (C/Co)is:                    8E-05
-----------------------------------------------------------
Continue Calculations (y/n) ? y


Time(yrs): 750
-----------------------------------------------------------
1st Argument(Y1)is:                          2.78685
1st Error Function is:                        0.99979
2nd Argument(Y2)is:                           0.64312
2nd Error Function is:                        0.63658
Exit/Source Concentration Ratio  (C/Co)is:                    2.2E-04
-----------------------------------------------------------
Continue Calculations (y/n) ? y


Time(yrs): 1000
-----------------------------------------------------------
1st Argument(Y1)is:                          2.72291
1st Error Function is:                        0.99973
2nd Argument(Y2)is:                           0.24754
2nd Error Function is:                        0.27399
Exit/Source Concentration Ratio  (C/Co)is:                    3.7E-04
-----------------------------------------------------------
Continue Calculations (y/n) ? y


Time(yrs): 2000
-----------------------------------------------------------
1st Argument(Y1)is:                          2.80056
1st Error Function is:                        0.9998
2nd Argument(Y2)is:                          -0.70014
2nd Error Function is:                        0
Exit/Source Concentration Ratio  (C/Co)is:                    4.2E-04
-----------------------------------------------------------
Continue Calculations (y/n) ? y


Time(yrs): 5000
-----------------------------------------------------------
1st Argument(Y1)is:                          3.43176
1st Error Function is:                        0.99998
2nd Argument(Y2)is:                          -2.10334
2nd Error Function is:                        0
Exit/Source Concentration Ratio  (C/Co)is:                    3.3E-04
-----------------------------------------------------------
Continue Calculations (y/n) ? n
```

1704 Morton Street
Ann Arbor, MI 48104

16 February 1984

Mr. David S. Miller
Mining Properties Department
Rouge Steel Company
3001 Miller Road
Dearborn, MI 48121

RE: Allen Park Clay Mine/Landfill

Dear Dave:

I have reviewed the memorandum dated January 23, 1984, from
Terry McNiel, Technical Services Section, to Larry Aubuchon,
Compliance Section, Detroit District, MDNR. The memorandum
essentially raises the following objections to the findings
and conclusions in my report, viz.,

Objection 1. There is no substantiation nor literature cita-
tions to show that organics present in the waste will not in-
crease permeability.

Objection 2. The presence and possible effects of napthalene
in the waste are disregarded.

Objection 3. Uncertainties remain about the actual composition
and likely nature of the leachate.

Objection 4. The report does not address the question of com-
patibility between the following:
   a) Leachate and leachate collection system components
   b) Generated gases and clay cap.

In the opinion of the MDNR reviewer Objections 1,2,and 3
taken together mean that Specific Condition 5.A.4 (a) of Act
64 license is not satisfied. The reviewer goes on to say,
however, that they (MDNR) would accept compatibility testing
between actual leachate being generated and the on-site clay
being used for containment. I will respond herein to these
stated objections and opinion. Objection 4 which pertains to
Specific Condition 5.A.4 (b) and (c) is outside the scope and
original charge of my investigation.

Objection 1 is a version of the "guilty until proved innocent"
syndrome. I understand and even sympathize with this approach
in matters which deal with the release of potentially hazardous
substances into the environment. There is, however, considerable
substantiation in the published technical literature for the
contention that organics present in low concentrations in aequous
leachate will not increase the permeability of dense clays.

Leachate permeability tests on sand-clay columns packed to bulk
densities within the range of densities of natural clays (Cart-
wright et al., 1977) have shown that permeability actually
decreased with passage of leachate (containing organics). These
tests were continued for periods up to nine months. Decreases
were even more pronounced for raw, unsterilized leachate. In
addition to permeability reduction from the passage of leachate,
Griffin and Shimp (1976) have shown that heavy metal ions (Pb,
Zn, Cd, Hg) are strongly attenuated by clay. Organics that
were present in the leachate were only moderately attenuated
by the clay; they did not increase hydraulic conductivity.
We have also conducted long term leachate permeability tests
ourselves on a silty clay almost identical in composition to
the clay underlying the Allen Park Clay Mine/Landfill site
(Gray, 1982) and found the same results, i.e., no increase in
permeability was observed. A chemical analysis of the leachates
used in all these permeability tests is attached. Note the
presence of napthalene in one of the leachates--a constituent
whose presence and influence the MDNR reviewer claimed we had
not considered. /Note: Cited references are listed in an
attachment to this letter report./

It is important to emphasize again the fact that leachate per-
meability tests conducted by Anderson (1982) are totaly unrepre-
sentative of conditions at the Allen Park site. These tests
are often cited as an example of the deleterious influence of
organic solvents on clay liner permeability. Anderson's tests
are unrepresentative and irrelevant for the following reasons:

1. He used pure organic solvents. The leachate at the
   Allen Park Clay Mine/Landfill will be an aequous extract
   containing very low concentrations of organics.

2. He forced the solvents through clays at extremely
   high, positive gradients. Anderson used positive grad-
   ients ranging from 60 to 300. At the Allen Park site
   there will be negative (reverse) gradients ranging on
   the order of -0.3 (worst case) to -2.7.

Other objections can also be cited in regard to Anderson's test
procedures and results. He used a rigid wall permeameter which
permits channeling between sample and container. The recommended
procedure to avoid this potential problem is to use a flexible,
pressurized jacket. Large reported increases in permeability
should be viewed with some skepticism when rigid wall permea-
meters have been employed.

Green et al. (1981) have investigated in great detail the char-
ateristics of organic solvents that affect their rate of movement
(permeability) in compacted clay. They measured the equilibrium
permeability of three clays (a clay shale, a fire clay, and
kaolinite) to the following solvents: benzene, xylene, carbon
tetrachloride, trichloroethylene, acetone, methanol, glycerol,
and water. Their study showed that it is the hydrophilic or

hydrophobic nature of the solvent (as measured by the octanol/
water partitioning coefficient or roughly by the dielectric
constant) and not the viscosity/density ratio that is important
in predicting a solvents rate of flow through clays. According
to their findings water, which has a high dielectric constant,
always exhibited the highest permeability. In addition, they
found that the packed clay density is crucial in determining
how permeable a clay will be to a given solvent. At high bulk
densities (on the order of 115 pcf or 1.85 g/cc) the solvent
characteristics became less important in differentiating per-
meability response.

Green et al. (1981) also observed that solvents of low dielec-
tric constant (e.g. xylene and carbon tetrachloride) tended
to cause shrinkage and cracking of some of the clays. This
phenomenon, known as syneresis, can and eventually did cause
an apparent permeability increase in some of the clays that
were tested. The same phenomenon was reported by Anderson(1982)
in some of his experiments. It must be emphasized again,
however, that the effect has only been observed and reported
when several pore volumes of pure, low-dielectric organic solvents
are forced at very high gradients through clay columns. These
conditions simply do not occur at the Allen Park Clay Mine/Land-
fill site.

On the contrary, the conditions at the Allen Park site are ideal
for effective containment, viz.,

1. The site is underlain by a thick (X $\geq$ 25 ft) section
   of dense, competent silty clay (γ_b = 115 pcf) with
   a very low hydraulic conductivity (k = 2 x 10^{-8} cm/sec)

2. A negative hydraulic gradient exists at the site as
   result of artesian conditions in the underlying aquifer.
   Even under worst case assumptions (viz., leachate levels
   rising to the top of the landfill) a negative gradient
   of -0.3 will still be present.

3. The leachate consists of very low concentrations of
   organic and inorganic solutes in an aqueous solution
   as opposed to a pure solvent.

Under these conditions advective transport or hydraulic seepage
ceases to dominate pollutant movement across a clay barrier
(see Gilbert and Cherry, 1983; Tallard, 1984). Instead, diffu-
sion under chemical concentration gradients becomes more impor-
tant, and it is this transport mechanism that must be evaluated
carefully. I have dealt with this problem both in my original
report and in my subsequent letter report to Mr. Mark Young,
Wayne Disposal, Inc., dated 25 September 1983. I showed that
even under worst case assumptions of no partitioning or attenua-
tion of pollutants and minimum, negative hydraulic gradients
breakthrought times would be on the order of thousands of years.
Interestingly, if the calculations are repeated allowing the

hydraulic conductivity or permeability to double or even triple, the breakthrough time increase even more because now the counter advective flow is more effective in opposing the downward diffusion of solutes along their concentration gradient.
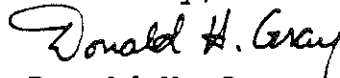
I come now to the MDNR comments about requiring compatibility testing (whatever that means) between actual leachate and the clay liner material. Unfortunately, the procedure, rationale, etc. for such tests are not specified. What is being required ...that the leachate be forced under high hydraulic gradients through a thin sample of the silty clay? The results or significance of such a test would be ambiguous at best and meaningless at worst in this case. In my opinion, such tests would be an exercise in futility and irrelevance given the condition and circumstances at the Allen Park Clay Mine/Landfill site.

Breakthrough times in diffusion controlled transport are extremely sensitive to thickness of the barrier. In order to replicate conditions in the field at Allen Park, compatibility or flow tests should be run on a sample column 25 feet high under a _negative_ gradient no less than -0.3. After a wait time of thousands of years such a test would merely confirm what is already demonstrable.

It is my professional opinion that in this instance the requirement for compatibility testing and concern over permeability is a diversion from the real issue which is the likelihood of diffusion transport of solute across the clay. I have shown that this will not be a problem at the Allen Park Clay Mine/Landfill site because of the thickness, competency, and density of the underlying clay together with the existence of a negative gradient.

I find it baffling that MDNR can approve a thin, clay slurry wall for a toxic waste site (see Consent Judgment, U.S. District Court, U.S. Envl. Protection Agency and The State of Michigan, Plaintiffs, vs. Velsicol Chemical Corp., Defendant) based on meagre and inadequate evaluation whilst insisting on irrelevant tests for a thick, natural clay containment system at Allen Park that is ideal in nearly every respect.

Sincerely,

Donald H. Gray
Professor of Civil Engineering

Attachments

ATTACHMENT NO. 1 - CITED REFERENCES

Anderson, D. (1982).   Does landfill leachate make clay liners
     more permeable?   Civil Engineering, ASCE, Vol. 52, pp.
     66-69

Cartwright, K., Griffin, R.A., and Gilkeson, R.H.   Migration
     of landfill leachate through glacial tills, Groundwater,
     Vol. 15, No. 4, pp. 294-305

Gilham, R.W. and Cherry, J.A. (1983).   Predictability of solute
     transport in diffusion-controlled hydrogeologic regimes,
     Proceedings, Symposium on Low-Level Waste Disposal, U.S.
     NRC, NUREG/CP-0028, Conf-820911, Vol. 3, pp. 379-410

Gray, D.H. (1982).   Influence of leachate on clay liner permea-
     bility, Wayne Disposal landfill site, Report prepared for
     Wayne Disposal, Inc., September 1982

Green, W.J., Lee, F.G., and Jones, R.A. (1981).   Clay-soils
     permeability and hazardous waste storage, Journal of WPCF,
     Vol. 53, No. 8, pp. 1347-1354

Griffin, R.A. and Shimp, N.F. (1976).   Attenuation of pollutants
     in municipal landfill leachate by clay minerals, Cincinnati
     Ohio: Final Report for U.S. Envl Protection Agency, Contract
     68-03-0211

Tallard, G. (1984).   Slurry trenches for containing hazardous
     wastes, Civil Engineering, ASCE, Vol. 54, No. 2, pp. 41-45

Table 2.   Chemical Analysis of Landfill Leachates

Analysis	DuPage County Landfill-mg/l	Wayne Disposal Landfill-mg/l
Na	748	3400
K	501	-
Ca	47	46
Mg	233	370
Cu	<0.1	0.55
Zn	18.8	5.0
Pb	4.46	0.91
Cd	1.95	0.10
Ni	0.3	0.40
Hg	0.0008	0.010
Cr	<0.1	0.31
Fe	4.2	7.77
Mn	<0.1	-
Al	<0.1	-
NH$_4$	862	1540
As	0.11	0.0044
B	29.9	<0.005
Si	14.9	-
Cl	3484	5800
SO$_4$	<0.1	200
NO3	-	<0.1
HCO$_3$	-	6920
COD	1340	2160
TOC	-	2500
TSS	-	512
pH	6.9	7.6
Spec. Cond. (mmhos/cm)	10.2	28.0
Equiv. TDS	6528	17,920
Organics:		
organic acids (phenol)	0.3	3.6
toluene	-	0.45
napthalene	-	0.44
chlorobenzene	-	0.008

L. M. MILLER & ASSOCIATES

CONSULTING ENGINEERS & GEOLOGISTS

2500 PACKARD RD., SUITE #106
ANN ARBOR, MICHIGAN 48104

June 17, 1982

Rouge Steel Company
Division of Mining Properties
3001 Miller Road
P.O. Box 1699
Dearbor, Mi   48121

Attention: Mr. David Miller

Re: Allen Park Clay Mine Seismic Survey

Dear Mr. Miller:

As per your request a seismic study was performed at the Allen
Park Clay Mine area in Allen Park, Michigan. The purpose of this study
was an attempt to determine the depth to bedrock in the area immediately
below the excavated pit at the disposal area.

Keeping consistent with previous seismic work accomplished in
the area these stations were numbered 4, 5 and 6. Stations 4 and 5 were
completed on the excavated pit floor, 4 being on the eastern half and 5 on
the western side of the pit floor, with station 6 directly to the north of the
pit up on approximately the existing surface elevation, some 30 to 40 feet
above the pit floor. Plots of the data collected are included and indicate
both the velocities of the layers and the depths to the layer interfaces.

Station 4 resulted in the best data collected at the site, and
shows a three-layer case. A low velocity (1428 ft/sec) layer is underlain
by a very consistent layer with a velocity of 5233 ft/sec, extending to a
depth of 57 feet below the pit floor where it is underlain by a much higher
velocity (12,808 ft/sec) layer. These values are very typical of a dense
clay layer underlain by a hard limestone type material. The rather good
fit of the data to a line would indicate very consistent materials, however,
the irregularities near the 57 foot contact indicate that this interface is not
as sharp a transition and hence it represents more of a minimum depth to
this interface.

At Station 5 area surface topography was rough and inconsistent
which resulted in limited data being collected. In one area a very steep
depression was encountered on the surface which the shock wave source
worked in. This abrupt lowering of the elevation causes a decrease in the
time it takes to the shock wave to travel through the subsurface. There-
fore, the best fit line was drawn through only those points where the shock
wave source was at the approximate same elevation. Had the elevation been
consistent, the travel times for those distances, which were lower, would have
been increased in the direction towards this line.

Station 5 showed approximately the same subsurface conditions as did 4, with a depth to the bedrock being indicated at 70 feet below the pit floor. Station 6 was run at a much higher elevation than that of the pit floor, and very soft wet surface conditions were found. These types of surface conditions do not allow for seismic shock waves to propogate as the material tends to absorb much of the energy and transmit this energy directly across the surface rather than down into the earth. This data indicates again a rather consistent layer with a velocity typical of a dense clay. As a rule of thumb, seismic tests measure in depth roughly one-third the distance from the energy source to the geophone. Using this rule the limits of our data would be to a depth of approximately 45 feet for the clay layer and would obviously extend until the next layer is encountered.

We hope that this information is useful to you. If any further information on subsurface conditions is needed, it should be noted that there is enough room in the bottom of the excavated pit for an electrical resistivity test to be run. The problems caused by surface conditions could be avoided and with the large contrast in the subsurface materials this test would most likely work well.

If we can be of any further assistance, please let us know.

Very truly yours,

L. M. MILLER & ASSOCIATES

Timothy P. Wilson, Geologist

TPW:hrh

Attachments as mentioned above.

ALLEN PARK CLAY MINE
SEISMIC STATION #1
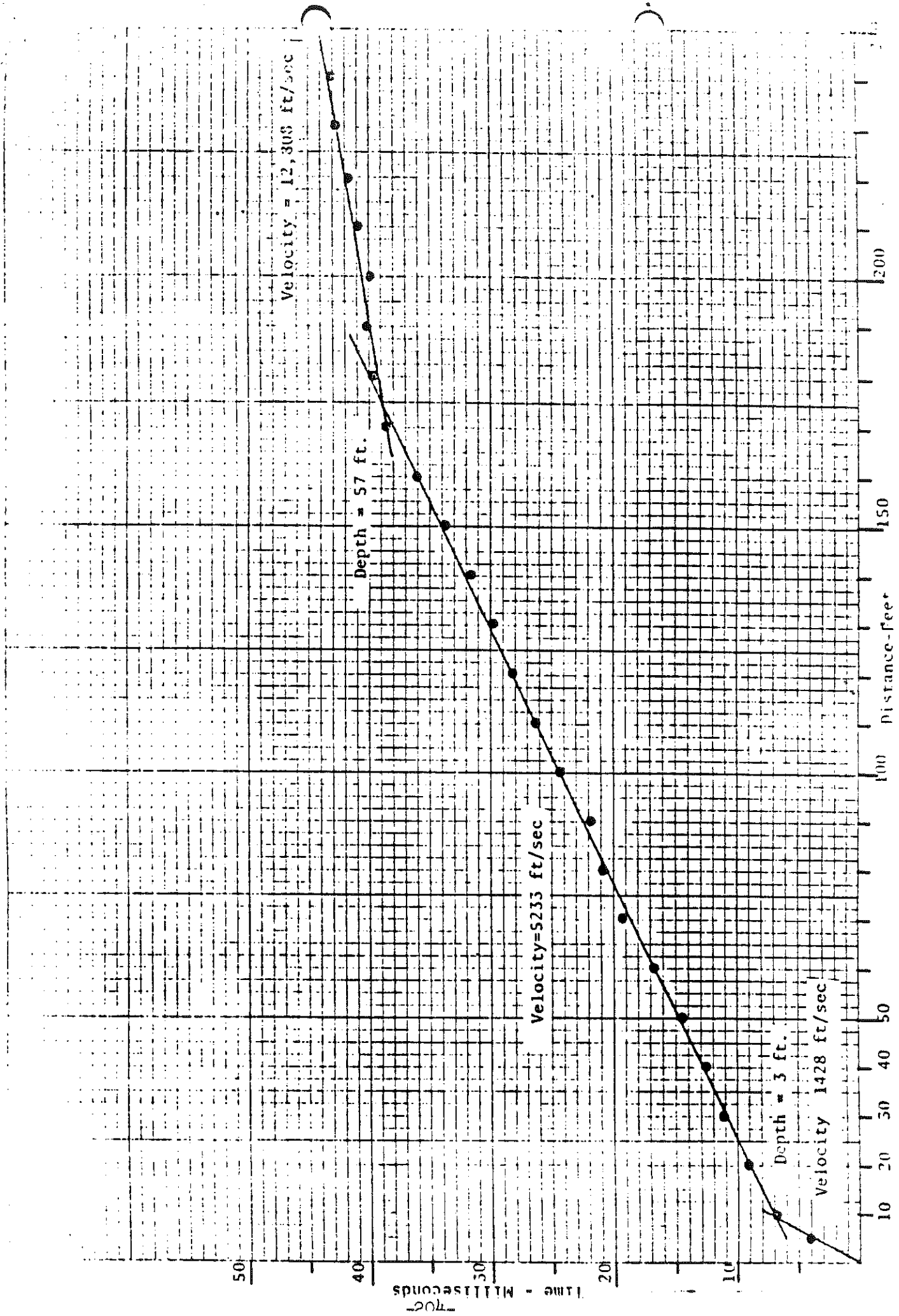
L. M. MILLER & ASSOCIATES

Velocity = 12,305 ft/sec

Depth = 57 ft.

Velocity=5233 ft/sec

Depth = 3 ft.

Velocity 1428 ft/sec

Distance-Feet

Time - Milliseconds

L. M. MILLER & ASSOCIATES

ALLEN PARK CLAY MINE
SEISMIC STATION #5

Velocity = 15,907 ft/sec

Depth = 70 ft.

Velocity = 5273 ft/sec

Depth 13.4'

Velocity = 2845 ft/sec

TOPOGRAPHY LOW IN THIS AREA
RESULTING IN A DECREASE OF
SEISMIC TIMES

Distance-Feet

Time - Milliseconds

-205-

SEISMIC STATION 4

Velocity = 5418 ft/sec

Depth = 21 ft.

Velocity = 1785 ft/sec

Distance-Feet

150

100

50

40

30

20

10
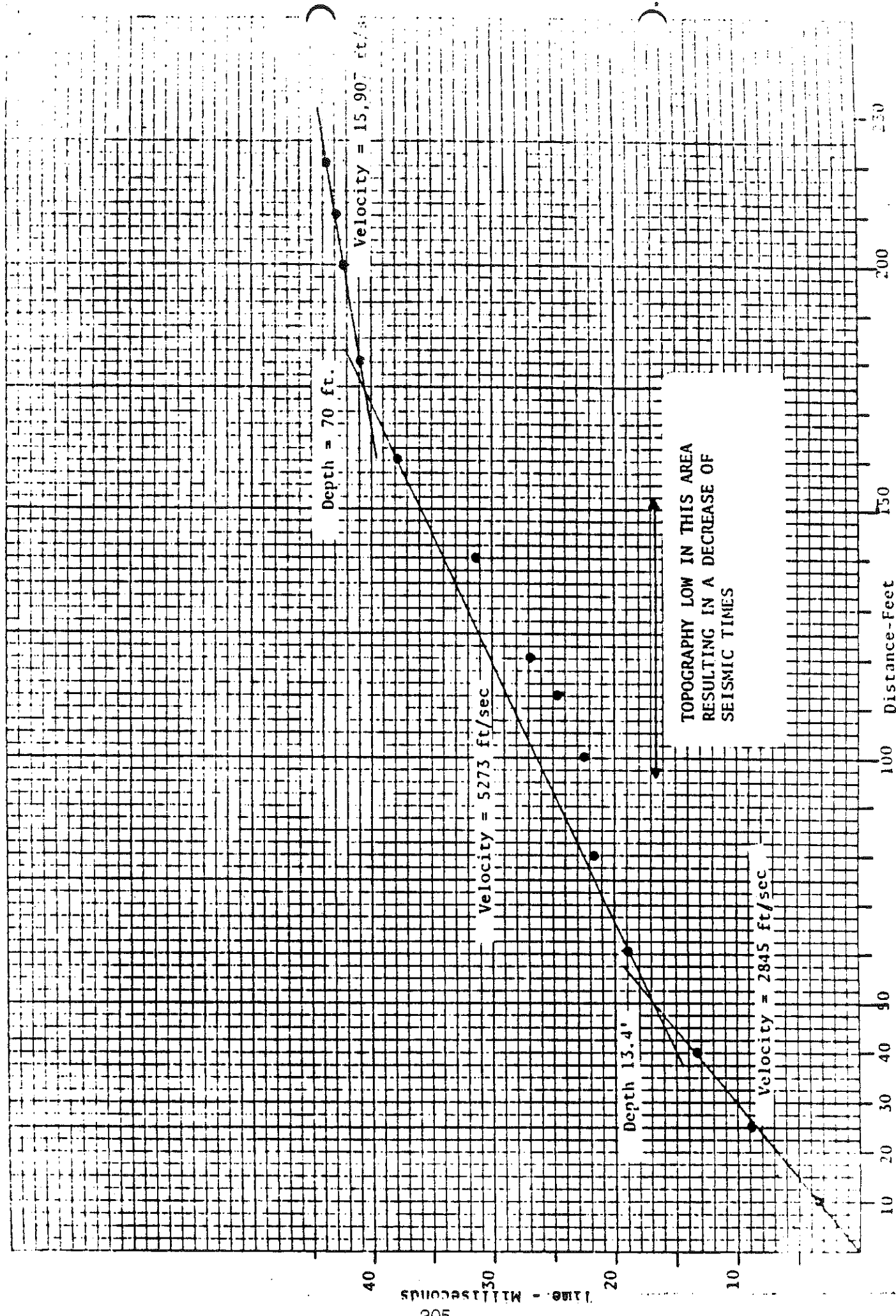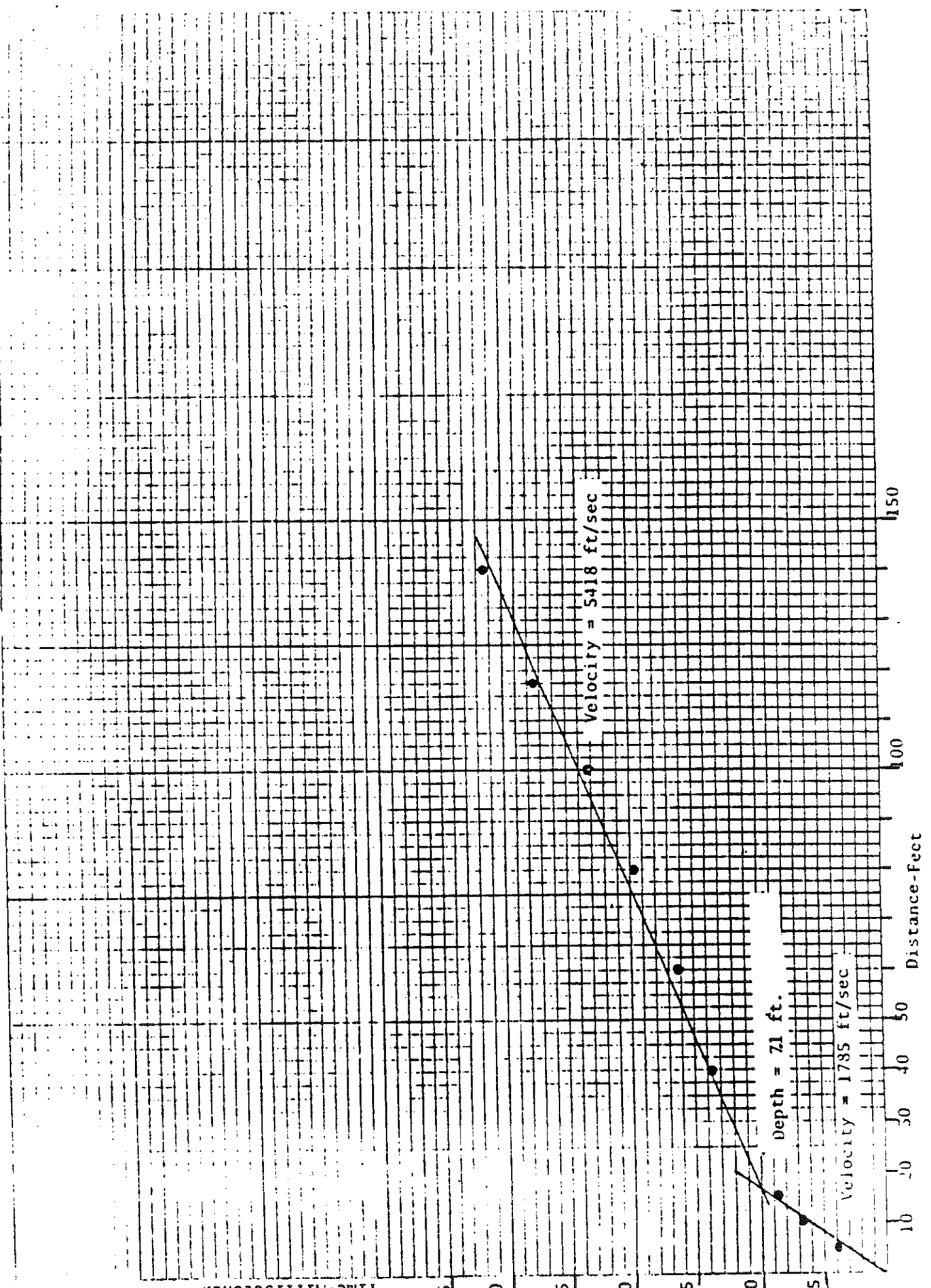
MICHIGAN TESTING ENGINEERS, INC.

24355 CAPITOL AVENUE • DETROIT, MICHIGAN 48239

PHONE: (313) 255-4200

SOILS EXPLORATIONS AND FOUNDATION ENGINEERING
MATERIALS TESTING AND INSPECTION
NON-DESTRUCTIVE TESTING and MATERIALS EVALUATION

June 25, 1982

Michigan Department of Natural Resources
Resource Recovery Division
P.O. Box 30028
Lansing, Michigan 48909

Attn: Mr. James Janiczek

Subject: Allen Park Clay Mine
         Allen Park, Michigan
         MTE File #406-15046

Gentlemen:

As requested, we have reviewed the above referenced file to determine the degree of saturation of the subsoils on the site.

The following basic soil relationships were used in this review:

$$s = \frac{wG_s}{e}$$

$$e = \frac{G_s}{\gamma d} - 1$$

$$w = \frac{W_w}{W_s}$$

Where: s = degree of saturation (%)
        w = moisture content of soil (%)
        e = void ratio
        W_w = weight of water
        W_s = weight of solids
        γ_d = dry unit weight of soil
        G_s = specific gravity of solids
            (assumed to be 2.65 to 2.68)

Utilizing these procedures, our calculations indicate the gray silty clays on the Allen Park Clay Mine to be 100% saturated.
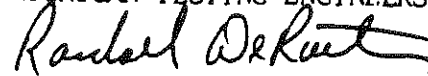
If there are any questions, please do not hesitate to call.

Very truly yours,

MICHIGAN TESTING ENGINEERS, INC.

Randall DeRuiter

RD/ksb

cc: D. Miller, Ford Motor Company
     W. Tomyn, Wayne Disposal

WILLIAM G MILLIKEN, Governor

DEPARTMENT OF NATURAL RESOURCES

HOWARD A TANNER, Director

November 4, 1981

Mr. Marshall Austin
Michigan Testing Engineers, Inc.
24355 Capitol Avenue
Detroit, Michigan 48239

RE: Permeability testing of clay soils
Allen Park Clay Mine; Allen Park, Michigan
Wayne County

Dear Marshall:

Based on the review of the soil tests performed (grain size analysis, atterberg limits and permeability) on the clay at the Allen Park Clay Mine Landfill, it is the feeling of this office that the materials are uniform enough that no further permeability testing will be required. This portion of our evaluation has been satisfied with the information submitted.

If you have any questions, please feel free to call.

Very truly yours,

RESOURCE RECOVERY DIVISION

James Janiczek
Geologist

JJ:nm

cc: Shakir/Belobraidich
Mark Young, Wayne Disposal
Wayne County Health Department

R-1026-6 10/80

E-2   <u>Interim Status Groundwater Monitoring Data</u> 40 CFR 270.14(c)(1),
                                                          40 CFR 265.90
                                                          40 CFR 265.94

During the facility's initial year of Interim Status (November 1980 -
November 1981), a hydrogeological study was performed on the site which
included the installation of five monitor wells in satisfaction of
Federal and State regulations. Quarterly samples were then taken to
provide initial background data, while at the same time additional in-
formation was being obtained to demonstrate that there is no potential
for migration of liquid from the regulated unit to the uppermost
aquifer during the active life of the unit.

Groundwater monitoring data obtained during Interim Status is provided
in Attachment 16. The data is grouped as follows:

. EPA Primary Interim Status

   Drinking Water Standards Appendix III   page 212

. Contamination Indicating Parameters   page 221

. Additional Water Quality Parameters   page 226

Allen Park Clay Mine

Ground Water Monitoring Data

Drinking Water and Water Quality Parameters

Well: 2-D Down Gradient

Date Sampled: 08-18-81

Parameter	Units	
Static	Feet	600.67
Arsenic	mg/l	<0.0003
Barium	mg/l	<0.100
Cadmium	mg/l	0.240
Chromium	mg/l	<0.010
Fluoride	mg/l	0.940
Lead	mg/l	<0.050
Mercury	mg/l	<0.0002
Nitrate	mg/l	<0.100
Selenium	mg/l	<0.0003
Silver	mg/l	<0.010
Endrin	ug/l	<0.0003
Lindane	ug/l	<0.004
Methoxychor	ug/l	<0.010
Toxaphene	ug/l	<0.005
2,4-D	ug/l	<0.100
2,4,5-TP/Silvex	ug/l	<0.001
Radium	pCi/l	<5.00
Gross Alpha	pCi/l	<5.00
Gross Beta	pCi/l	<5.00
Coliform Bact.	co/100ml	2.00
Chloride	mg/l	150.
Iron	mg/l	<0.030
Manganese	mg/l	<0.010
Phenols	mg/l	0.008
Sodium	mg/l	110.
Sulfate	mg/l	1050.

Time of Execution: 06/18/84 1510.0 out Mon

Allen Park Clay Mine

Ground Water Monitoring Data

Drinking Water and Water Quality Parameters

Well: 2-D Down Gradient

Date Sampled: 05-06-82 07-14-82 11-26-82

Parameter	Units			
Static	Feet	599.01	600.68	600.66
Arsenic	mg/l	<0.010	<0.001	<0.001
Barium	mg/l	<0.040	<0.020	<0.100
Cadmium	mg/l	0.023	0.006	<0.003
Chromium	mg/l	0.050	0.011	0.016
Fluoride	mg/l	0.800	0.800	0.900
Lead	mg/l	0.093	0.030	<0.010
Mercury	mg/l	<0.0002	<0.0002	<0.0002
Nitrate	mg/l	<0.010	0.010	<0.010
Selenium	mg/l	<0.010	<0.010	<0.010
Silver	mg/l	0.018	0.004	0.008
Endrin	ug/l	<0.100	<0.100	<0.100
Lindane	ug/l	<0.100	<0.100	<0.100
Methoxychor	ug/l	<0.500	<0.500	<0.500
Toxaphene	ug/l	<1.00	<1.00	<1.00
2,4-D	ug/l	<0.100	<0.100	<0.100
2,4,5-TP/Silvex	ug/l	<0.050	<0.050	<0.050
Radium	pCi/l	<5.00	<5.00	<5.00
Gross Alpha	pCi/l	<5.00	<5.00	<5.00
Gross Beta	pCi/l	<4.00	<8.00	<8.00
Coliform Bact.	co/100ml	<2.00	<4.00	<2.20
Chloride	mg/l	170.	170.	170.
Iron	mg/l	5.10	0.840	0.450
Manganese	mg/l	0.130	0.023	0.024
Phenols	mg/l	0.004	<0.004	<0.004
Sodium	mg/l	120.	110.	240
Sulfate	mg/l	870.	1000.	880.

Allen Park Clay Mine

Ground Water Monitoring Data

Drinking Water and Water Quality Parameters

Well: 5-D Up Gradient

Date Sampled: 05-06-82 07-14-82 10-28-82

Parameter	Units			
Static	Feet	605.12	605.45	604.64
Arsenic	mg/l	<0.010	<0.001	<0.001
Barium	mg/l	0.068	<0.020	<0.050
Cadmium	mg/l	0.006	<0.003	<0.003
Chromium	mg/l	<0.005	0.015	0.019
Fluoride	mg/l	1.30	1.00	1.00
Lead	mg/l	0.010	<0.010	0.071
Mercury	mg/l	<0.0002	0.0005	<0.0002
Nitrate	mg/l	0.010	0.250	<0.010
Selenium	mg/l	<0.010	<0.010	<0.010
Silver	mg/l	0.003	<0.003	<0.003
Endrin	ug/l	<0.100	<0.100	<0.100
Lindane	ug/l	<0.100	<0.100	<0.100
Methoxychlor	ug/l	<0.500	<0.500	<0.500
Toxaphene	ug/l	<1.00	<1.00	<1.00
2,4-D	ug/l	<0.100	<0.100	<0.100
2,4,5-TP/Silver	ug/l	<0.050	<0.050	<0.050
Radium	pCi/l	<2.00	<5.00	<5.00
Gross Alpha	pCi/l	<5.00	<5.00	<5.00
Gross Beta	pCi/l	<4.00	<4.00	<8.00
Coliform Bact.	co/100ml	<2.00	<4.00	4.00
Chloride	mg/l	140.	150.	140.
Iron	mg/l	1.70	1.20	0.880
Manganese	mg/l	0.023	0.015	0.006
Phenols	mg/l	<0.004	<0.004	<0.004
Sodium	mg/l	85.6	88.0	180.
Sulfate	mg/l	190.	200.	70.0

Time of Execution: 06/18/84 1510.0 edt Mon

Allen Park Clay Mine

Ground Water Monitoring Data

Drinking Water and Water Quality Parameters

Well: 102-D Down Gradient

Date Sampled: 08-18-81

Parameter	Units	
Static	Feet	603.22
Arsenic	mg/l	(0.0003
Barium	mg/l	(0.100
Cadmium	mg/l	(0.010
Chromium	mg/l	(0.010
Fluoride	mg/l	1.42
Lead	mg/l	(0.050
Mercury	mg/l	(0.0002
Nitrate	mg/l	(0.100
Selenium	mg/l	(0.0003
Silver	mg/l	(0.010
Endrin	ug/l	(0.0002
Lincane	ug/l	(0.004
Methoxychor	ug/l	(0.010
Toxaphene	ug/l	(0.005
2,4-D	ug/l	(0.100
2,4,5-TP/Silvex	ug/l	(0.001
Radium	pCi/l	(5.00
Gross Alpha	pCi/l	(5.00
Gross Beta	pCi/l	(5.00
Coliform Bact.	co/100ml	4.00
Chloride	mg/l	130.
Iron	mg/l	(0.030
Manganese	mg/l	(0.010
Phenols	mg/l	(0.005
Sodium	mg/l	100.
Sulfate	mg/l	1200.

Time of Execution: 06/18/84 1510.0 edt Mon

Allen Park Clay Mine

Ground Water Monitoring Data

Drinking Water and Water Quality Parameters

Well: 102-D Down Gradient

Date Sampled: 05-06-82 07-14-82 10-26-82

Parameter	Units			
Static	Feet	601.77	601.68	599.15
Arsenic	mg/l	<0.010	<0.001	<0.001
Barium	mg/l	<0.040	<0.020	<0.100
Cadmium	mg/l	0.006	<0.003	<0.003
Chromium	mg/l	<0.005	0.006	0.006
Fluoride	mg/l	1.30	1.00	1.00
Lead	mg/l	0.010	<0.010	0.010
Mercury	mg/l	<0.0002	<0.0002	<0.0002
Nitrate	mg/l	<0.010	0.270	<0.010
Selenium	mg/l	<0.010	<0.010	<0.010
Silver	mg/l	0.006	0.004	0.005
Endrin	ug/l	<0.100	<0.100	<0.100
Lindane	ug/l	<0.100	<0.100	<0.100
Methoxychor	ug/l	<0.050	<0.500	<0.500
Toxaphene	ug/l	<1.00	<1.00	<1.00
2,4-D	ug/l	<0.100	<0.100	<0.100
2,4,5-TP/Silvex	ug/l	0.050	<0.050	<0.050
Radium	pCi/l	<5.00	<5.00	<5.00
Gross Alpha	pCi/l	<5.00	<5.00	<5.00
Gross Beta	pCi/l	<8.00	<4.00	<6.00
Coliform Bact.	co/100ml	<2.00	<4.00	<2.20
Chloride	mg/l	140.	140.	140.
Iron	mg/l	0.530	5.10	1.20
Manganese	mg/l	0.023	0.041	0.016
Phenols	mg/l	<0.004	<0.004	<0.004
Sodium	mg/l	95.0	97.0	200.
Sulfate	mg/l	910.	960.	810.

Time of Execution: 06/18/84 1510.0 edt Mon

Allen Park Clay Mine

Ground Water Monitoring Da a

Drinking Water and Water Quality Parameters

Well: 103-D Down Gradient

Date Sampled: 08-18-81

Parameter	Units	
---------	-----	
Static	Feet	603.52
Arsenic	mg/l	<0.0063
Barium	mg/l	<0.105
Cadmium	mg/l	<0.010
Chromium	mg/l	<0.010
Fluoride	mg/l	1.31
Lead	mg/l	<0.050
Mercury	mg/l	<0.0002
Nitrate	mg/l	<0.100
Selenium	mg/l	<0.0003
Silver	mg/l	<0.010
Endrin	ug/l	<0.0002
Lindane	ug/l	<0.004
Methoxychor	ug/l	<0.010
Toxaphene	ug/l	<0.005
2,4-D	ug/l	<0.100
2,4,5-TP/Silvex	ug/l	<0.001
Radium	pCi/l	<5.00
Gross Alpha	pCi/l	<5.00
Gross Beta	pCi/l	<5.00
Coliform Bact.	co/100ml	<2.00
Chloride	mg/l	25.0
Iron	mg/l	<0.030
Manganese	mg/l	<0.010
Phenols	mg/l	<0.005
Sodium	mg/l	6.00
Sulfate	mg/l	46.0

Time of Execution: 06/18/84 1510.0 edt Mon

-217-

Allen Park Clay Mine

Ground Water Monitoring Data

Drinking Water and Water Quality Parameters

Well: 103-D Down Gradient

Date Sampled: 05-06-82 07-14-82 10-26-82

Parameter	Units			
Static	Feet	603.65	601.23	601.25
Arsenic	mg/l	<0.001	<0.001	<0.001
Barium	mg/l	<0.020	<0.020	<0.200
Cadmium	mg/l	0.007	0.006	<0.003
Chromium	mg/l	0.020	<0.004	<0.005
Fluoride	mg/l	1.50	1.00	1.00
Lead	mg/l	<0.010	<0.010	<0.010
Mercury	mg/l	<0.0002	<0.0002	<0.0002
Nitrate	mg/l	<0.010	0.050	<0.010
Selenium	mg/l	<0.010	<0.010	<0.010
Silver	mg/l	0.005	0.003	0.007
Endrin	ug/l	<0.100	<0.100	<0.100
Lindane	ug/l	<0.100	<0.100	<0.100
Methoxychor	ug/l	<0.500	<0.500	<0.500
Toxaphene	ug/l	<1.00	<1.00	<1.00
2,4-D	ug/l	<0.100	<0.100	<0.100
2,4,5-TP/Silver	ug/l	<0.050	<0.050	<0.050
Radium	pCi/l	<2.00	<5.00	<5.00
Gross Alpha	pCi/l	<3.00	<5.00	<5.00
Gross Beta	pCi/l	<4.00	<4.00	<8.00
Coliform Bact.	co/100ml	<2.00	<4.00	5.10
Chloride	mg/l	130.	140.	130.
Iron	mg/l	1.00	0.900	6.00
Manganese	mg/l	0.023	0.018	0.037
Phenols	mg/l	<0.004	0.006	<0.004
Sodium	mg/l	8.70	85.0	160.
Sulfate	mg/l	760.	790.	840.

Time of Execution: 06/18/84 1510.0 edt Mon

-218-

Allen Park Clay Mine

Ground Water Monitoring Data

Drinking Water and Water Quality Parameters

Well: 104-D Down Gradient

Date Sampled: 08-18-81

Parameter	Units	
Static	Feet	603.81
Arsenic	mg/l	<0.0003
Barium	mg/l	<0.100
Cadmium	mg/l	<0.010
Chromium	mg/l	<0.010
Fluoride	mg/l	1.31
Lead	mg/l	<0.050
Mercury	mg/l	<0.0002
Nitrate	mg/l	<0.100
Selenium	mg/l	<0.0003
Silver	mg/l	<0.010
Endrin	ug/l	<0.0002
Lindane	ug/l	<0.004
Methoxychor	ug/l	<0.010
Toxaphene	ug/l	<0.005
2,4-D	ug/l	<0.100
2,4,5-TP/Silvex	ug/l	<0.001
Radium	pCi/l	<5.00
Gross Alpha	pCi/l	<5.00
Gross Beta	pCi/l	<5.00
Coliform Bact.	co/100ml	4.00
Chloride	mg/l	140.
Iron	mg/l	<0.030
Manganese	mg/l	0.060
Phenols	mg/l	<0.005
Sodium	mg/l	100.
Sulfate	mg/l	1350.

Date Sampled: 05-06-82 02-14-82 18 26-8.

Parameter	Units			
Static	Feet	604.32	604.32	604.1.
Arsenic	mg/l	(0.001	(0.010	(0.001
Barium	mg/l	(0.040	(0.020	(0.100
Cadmium	mg/l	0.010	(0.003	(0.003
Chromium	mg/l	(0.005	0.012	0.013
Fluoride	mg/l	1.00	0.900	1.00
Lead	mg/l	(0.010	(0.010	0.020
Mercury	mg/l	(0.0002	(0.002	(0.000.
Nitrate	mg/l	(0.010	0.230	0.250
Selenium	mg/l	(0.010	0.010	(0.010
Silver	mg/l	0.009	0.004	0.01.
Endrin	ug/l	(0.100	(0.100	(0.100
Lindane	ug/l	(0.100	(0.100	(0.100
Methoxychor	ug/l	(0.500	(0.500	(0.500
Toxaphene	ug/l	(1.00	(1.00	(1.00
2,4-D	ug/l	(0.100	(0.100	(0.100
2,4,5-TP/Silvex	ug/l	(0.050	(0.050	(0.050
Radium	pCi/l	(5.00	(5.00	(5.00
Gross Alpha	pCi/l	(3.00	(3.00	(5.00
Gross Beta	pCi/l	(4.00	(4.00	11.0
Coliform Bact.	co/100ml	(2.00	6.00	9.20
Chloride	mg/l	150.	160.	140.
Iron	mg/l	4.30	9.90	52.0
Manganese	mg/l	0.060	0.042	0.100
Phenols	mg/l	(0.004	(0.004	(0.004
Sodium	mg/l	100.	88.0	210.
Sulfate	mg/l	1200.	1300.	1200.

Time of Execution: 06/18/84 1510.0 edt Mon

Table 2

Allen Park Clay Mine

Ground Water Monitoring Data

Contamination Indicating Parameters

Well: 2-D Down Gradient

Well Background Sampling Data #

Date Sampled:	08-10-81	05-06-82	07-14-82	10-26-82

Parameter	Units				
Static	Feet	600.67	599.01	600.68	600.68
pH1		7.70	6.91	7.75	8.70
pH2		7.90	6.95	7.76	8.70
pH3		8.00	7.01	7.73	8.70
pH4		8.00	7.09	7.76	8.70
Number of Samples		4	4	4	4
Mean Value		7.90	6.99	7.75	8.70
Variance		2.00E-02	6.13E-03	2.00E-04	0.00E+00
Sp.Cond1	umhos/cm	2500.	2395.	3054.	2256.
Sp.Cond2	umhos/cm	2200.	2085.	2983.	2244.
Sp.Cond3	umhos/cm	2400.	2187.	2980.	2252.
Sp.Cond4	umhos/cm	2200.	2127.	2875.	2250.
Number of Samples		4	4	4	4
Mean Value		2325.0	2173.5	2973.0	2250.5
Variance		2.25E+04	8.31E+03	5.44E+03	2.50E+01
TOC1	mg/l	7.70	20.0	3.00	15.0
TOC2	mg/l	7.00	20.0	5.00	20.0
TOC3	mg/l	7.70	19.0	5.00	17.0
TOC4	mg/l	7.60	19.0	5.00	16.0
Number of Samples		4	4	4	4
Mean Value		7.50	19.50	4.50	17.00
Variance		1.13E-01	3.33E-01	1.00E+00	4.67E+00
TOX1	mg/l	<0.005	0.012	0.029	0.010
TOX2	mg/l	<0.005	0.016	0.033	0.017
TOX3	mg/l	<0.005	0.015	0.046	0.026
TOX4	mg/l	<0.005	0.014	0.027	0.038
Number of Samples		4	4	4	4
Mean Value		0.005	0.014	0.034	0.023
Variance		0.00E+00	2.92E-06	7.29E-05	1.46E-04

Summary of Background Data

Parameter	Mean Value	Variance	Number of Samples
pH:	7.84	3.98E-01	16
Sp.Cond:	2430.5	1.15E+05	16
TOC:	12.13	4.33E+01	16
TOX:	0.019	1.64E-04	16

Time of Execution: 02/23/83 0730.2 est Wed

Table 2 (Cont.)

Allen Park Clay Mine

Ground Water Monitoring Data

Contamination Indicating Parameters

Well: 102-D Down GraDient

* * Well Background Sampling Data * *

Date Sampled:	08-10-81	05-06-82	07-14-82	10-26-82

Parameter	Units				
Static	Feet	603.22	601.77	601.68	599.15
pH1		8.40	7.30	7.20	8.70
pH2			7.30	7.20	8.70
pH3			7.30	7.20	8.70
pH4			7.30	7.30	8.70
Number of Samples		1	4	4	4
Mean Value		8.40	7.30	7.22	8.70
Variance		0.00E+00	6.36E-07	2.50E-03	0.00E+00
Sp.Cond1	umhos/cm	2500.	2993.	2524.	2392.
Sp.Cond2	umhos/cm		2997.	2664.	2398.
Sp.Cond3	umhos/cm		2973.	2651.	2358.
Sp.Cond4	umhos/cm		2940.	2630.	2378.
Number of Samples		1	4	4	4
Mean Value		2500.0	2975.8	2617.3	2381.5
Variance		0.00E+00	6.78E+02	4.06E+03	3.16E+02
TOC1	mg/1	5.60	9.00	21.0	16.0
TOC2	mg/1		12.0	15.0	24.0
TOC3	mg/1		11.0	17.0	23.0
TOC4	mg/1		13.0	19.0	16.0
Number of Samples		1	4	4	4
Mean Value		5.60	11.25	18.00	19.75
Variance		0.00E+00	2.92E+00	6.67E+00	1.89E+01
TOX1	mg/1	0.008	0.011	0.035	0.015
TOX2	mg/1		0.006	0.010	<0.010
TOX3	mg/1		0.006	0.010	0.016
TOX4	mg/1		0.007	0.010	0.013
Number of Samples		1	4	4	4
Mean Value		0.008	0.008	0.016	0.014
Variance		0.00E+00	5.67E-06	1.56E-04	7.00E-06

Summary of Background Data

Parameter	Mean Value	Variance	Number of Samples
pH:	7.79	4.94E-01	13
Sp.Cond:	2646.8	6.29E+04	13
TOC:	15.51	2.94E+01	13
TOX:	0.012	5.71E-05	13

Time of Execution: 02/23/83 0730.2 est Wed

Table 2 (Cont.)

Allen Park Clay Mine

Ground Water Monitoring Data

Contamination Indicating Parameters

Well: 103-D Down Gradient

 # # Well Background Sampling Data # #

Date Sampled:		08-10-81	05-06-82	07-14-82	10-26-82
Parameter	**Units**				
Static	Feet	603.52	603.65	601.23	601.26
pH1		8.60	7.02	7.70	8.70
pH2			7.09	7.70	8.70
pH3			7.11	7.70	8.70
pH4			7.12	7.70	8.70
Number of Samples		1	4	4	4
Mean Value		8.60	7.09	7.70	8.70
Variance		0.00E+00	2.03E-03	0.00E+00	0.00E+00
Sp.Cond1	umhos/cm	300.	2632.	2441.	2352.
Sp.Cond2	umhos/cm		2604.	2468.	2308.
Sp.Cond3	umhos/cm		2583.	2450.	2294.
Sp.Cond4	umhos/cm		2616.	2438.	2288.
Number of Samples		1	4	4	4
Mean Value		300.0	2606.3	2449.3	2310.5
Variance		0.00E+00	2.96E+02	1.82E+02	8.36F+02
TOC1	mg/l	5.60	4.00	12.0	26.0
TOC2	mg/l		5.00	14.0	21.0
TOC3	mg/l		6.00	14.0	22.0
TOC4	mg/l		6.00	9.00	21.0
Number of Samples		1	4	4	4
Mean Value		5.60	5.25	12.25	22.50
Variance		0.00E+00	9.17E-01	5.58E+00	5.67E+00
TOX1	mg/l	0.029	<0.005	0.010	0.010
TOX2	mg/l		<0.005	0.054	0.010
TOX3	mg/l		<0.005	0.010	0.014
TOX4	mg/l		<0.005	0.010	<0.010
Number of Samples		1	4	4	4
Mean Value		0.029	0.005	0.021	0.011
Variance		0.00E+00	0.00E+00	4.84E-04	4.00F-06

Summary of Background Data

Parameter	Mean Value	Variance	Number of Samples
pH:	7.89	4.89E-01	13
Sp.Cond:	2289.5	3.72F+05	13
TOC:	12.74	5.78E+01	13
TCX.	0.014	1.87E-04	13

Time of Execution: 02/23/63 0749.7 est Wed

Table 2 (Cont.)

Allen Park Clay Mine

Ground Water Monitoring Data

Contamination Indicating Parameters

Well: 104-D Down Gradient

Well Background Sampling Data #

Date Sampled: 08-10-81 05-06-82 07-14-82 10-26-82.

Parameter	Units				
Static	Feet	603.81	604.32	604.32	604.12
pH1		8.00	6.89	7.70	8.30
pH2			6.90	7.68	8.20
pH3			6.91	7.68	8.20
pH4			6.90	7.67	8.20
Number of Samples		1	4	4	4
Mean Value		8.00	6.90	7.68	8.23
Variance		0.00E+00	6.61E-05	1.58E-04	2.50E-03
Sp.Cond1	umhos/cm	2550.	1980.	2817.	2678.
Sp.Cond2	umhos/cm		1960.	2885.	2862.
Sp.Cond3	umhos/cm		1980.	2885.	2639.
Sp.Cond4	umhos/cm		1920.	2852.	2871.
Number of Samples		1	4	4	4
Mean Value		2550.0	1960.0	2859.6	2857.3
Variance		0.00E+00	8.00E+02	1.05E+03	6.14E+02
TOC1	mg/l	6.60	7.00	6.00	11.0
TOC2	mg/l		10.0	12.0	15.0
TOC3	mg/l		8.00	14.0	10.0
TOC4	mg/l		8.00	12.0	12.0
Number of Samples		1	4	4	4
Mean Value		6.60	8.25	11.00	12.00
Variance		0.00E+00	1.58E+00	1.20E+01	4.67E+00
TOX1	mg/l	<0.005	<0.005	0.010	0.024
TOX2	mg/l		<0.005	0.024	0.018
TOX3	mg/l		<0.005	0.010	0.010
TOX4	mg/l		<0.005	0.048	0.020
Number of Samples		1	4	4	4
Mean Value		0.005	0.005	0.023	0.018
Variance		0.00E+00	0.00E+00	3.21E-04	3.47E-05

Summary of Background Data

Parameter	Mean Value	Variance	Number of Samples
pH:	7.63	3.09E-01	13
Sp.Cond:	2561.4	1.82E+05	13
TOC:	10.12	8.20E+00	13
TOX:	0.015	1.55E-04	13

Time of Execution: 02/23/83 0730.2 est Wed

Table 2 (Cont.)

Allen Park Clay Mine

Ground Water Monitoring Data

Contamination Indicating Parameters

Well: 5-D Up Gradient

		* * Well Background Sampling Data * *			
Date Sampled:		06-18-81	05-06-82	07-14-82	10-25-82

Parameter	Units				
Static	Feet	605.89	605.12	605.45	604.84
pH1		9.60	7.32	7.44	16.2
pH2			7.26	7.50	10.2
pH3			7.31	7.67	16.2
pH4			7.32	7.60	16.2
Number of Samples		1	4	4	4
Mean Value		9.60	7.31	7.55	16.25
Variance		0.00E-00	3.58E-04	1.25E-02	8.00E+00
Sp.Cond1	umhos/cm	1550.	2150.	1999.	1735.
Sp.Cond2	umhos/cm		2107.	1918.	1800.
Sp.Cond3	umhos/cm		2121.	1939.	1791.
Sp.Cond4	umhos/cm		2100.	1952.	1800.
Number of Samples		1	4	4	4
Mean Value		1550.0	2122.0	1950.2	1809.0
Variance		8.00E-00	6.99E+02	9.23E+02	1.17E+03
TOC1	mg/l	9.80	6.80	21.0	21.8
TOC2	mg/l		5.80	16.0	25.8
TOC3	mg/l		5.90	16.0	9.80
TOC4	mg/l		6.80	20.0	33.6
Number of Samples		1	4	4	4
Mean Value		9.80	5.80	19.20	20.75
Variance		8.00E+00	3.33E-01	2.25E+00	9.63E+01
TOX1	mg/l		0.006	0.064	0.021
TOX2	mg/l		0.010	0.032	0.041
TOX3	mg/l		0.009	0.024	0.025
TOX4	mg/l		0.008	0.026	0.032
Number of Samples		0	4	4	4
Mean Value			0.008	0.037	0.030
Variance			2.92E-06	3.48E-04	7.64E-05

Summary of Background Data

Parameter	Mean Value	Variance	Number of Samples
pH:	8.45	1.84E+00	13
Sp.Cond:	1929.8	3.81E+04	13
TOC:	14.69	7.41E+01	13
TOX:	0.025	2.70E-04	12

Allen Park Clay Mine.

Ground Water Monitoring Data

Additional Water Quality Parameters

Well: 2-D Down Gradient

Date Sampled: 08-10-81

Parameter	Units	
Static	Feet	600.67
COD	mg/l	2.60
Iron	mg/l	<0.030
Chloride	mg/l	150
Sulfate	mg/l	1050.
Sp. Conductance	umhos/cm	2500.
Sp. Conductance	umhos/cm	2400.
Sp. Conductance	umhos/cm	2200.
Sp. Conductance	umhos/cm	2200.
pH 1		7.70
pH 2		8.00
pH 3		7.90
pH 4		8.00
TOC 1	mg/l	7.70
TOC 2	mg/l	7.00
TOC 3	mg/l	7.70
TOC 4	mg/l	7.60
Calcium	mg/l	200.
Sodium	mg/l	110.
Magnesium	mg/l	160.
bicarbonate	mg/l	200.
Ammonia-Nitrogen	mg/l	0.500
Nitrogen-Nitrate	mg/l	<0.100
Nitrogen-Nitrite	mg/l	0.002
Phenols	mg/l	0.000
Chromium	mg/l	<0.010
Cadmium	mg/l	0.240
Lead	mg/l	<0.050
Napthalene	mg/l	

Allen Park Clay Mine

Ground Water Monitoring Data

Additional Water Quality Parameters

Well: 2-D Down Gradient

Date Sampled: 05-06-82 07-14-82 10-26-82

Parameter	Units			
Static	Feet	599.01	600.68	600.68
COD	mg/l			
Iron	mg/l	5.10	0.840	0.450
Chloride	mg/l	150.	170.	170.
Sulfate	mg/l	1050.	1000.	860.
Sp. Conductance	umhos/cm	2295.	3054.	2258.
Sp. Conductance	umhos/cm	2085.	2983.	2244.
Sp. Conductance	umhos/cm	2187.	2980.	2252.
Sp Conductance	umhos/cm	2127.	2875.	2250
pH 1		6.91	7.75	8.70
pH 2		6.95	7.72	8.70
pH 3		7.01	7.73	8.70
pH 4		7.09	7.76	6.70
TOC 1	mg/l	20.0	3.00	15.0
TOC 2	mg/l	20.0	5.00	20.0
TOC 3	mg/l	19.0	5.00	15.0
TOC 4	mg/l	19.0	5.00	16.0
Calcium	mg/l			
Sodium	mg/l	120.	110.	240.
Magnesium	mg/l			
Bicarbonate	mg/l			
Ammonia-Nitrogen	mg/l			
Nitrogen-Nitrate	mg/l	<0.010	0.010	<0.010
Nitrogen-Nitrite	mg/l			
Phenols	mg/l	0.004	<0.004	<0.004
Chromium	mg/l	0.050	0.010	0.016
Cadmium	mg/l	0.023	0.006	<0.003
Lead	mg/l	0.093	0.030	<0.010
Napthalene	mg/l			

Allen Park Clay Mine

Ground Water Monitoring Data

Additional Water Quality Parameters

Well: 2-D Down Gradient

Date Sampled: 04-26-83 08-24-83

Parameter	Units		
Static	Feet	600.74	600.67
COD	mg/l		110.
Iron	mg/l		2.20
Chloride	mg/l		170.
Sulfate	mg/l		1210.
Sp. Conductance	umhos/cm		2700.
Sp. Conductance	umhos/cm		2600.
Sp. Conductance	umhos/cm		2600.
Sp. Conductance	umhos/cm		2600.
pH 1			7.40
pH 2			7.40
pH 3			7.50
pH 4			7.60
TOC 1	mg/l		31.0
TOC 2	mg/l		14.0
TOC 3	mg/l		27.0
TOC 4	mg/l		32.0
Calcium	mg/l		340.
Sodium	mg/l		120.
Magnesium	mg/l		230.
Bicarbonate	mg/l		350.
Ammonia-Nitrogen	mg/l		1.10
Nitrogen-Nitrate	mg/l		0.040
Nitrogen-Nitrite	mg/l		<0.020
Phenols	mg/l		
Chromium	mg/l		<0.020
Cadmium	mg/l		
Lead	mg/l		0.440
Napthalene	mg/l		

Allen Park Clay Mine

Ground Water Monitoring Data

Additional Water Quality Parameters

Well: 2-D Down Gradient

Date Sampled: 04-17-84

Parameter	Units	
Static	Feet	586.97
COD	mg/l	118.
Iron	mg/l	3.38
Chloride	mg/l	170.
Sulfate	mg/l	2600.
Sp. Conductance	umhos/cm	2600.
Sp. Conductance	umhos/cm	
Sp. Conductance	umhos/cm	
Sp. Conductance	umhos/cm	
pH 1		7.60
pH 2		
pH 3		
pH 4		
TOC 1	mg/l	11.0
TOC 2	mg/l	
TOC 3	mg/l	
TOC 4	mg/l	
Calcium	mg/l	280.
Sodium	mg/l	118.
Magnesium	mg/l	150.
Bicarbonate	mg/l	320.
Ammonia-Nitrogen	mg/l	0.630
Nitrogen-Nitrate	mg/l	(0.020
Nitrogen-Nitrite	mg/l	0.020
Phenols	mg/l	
Chromium	mg/l	(0.020
Cadmium	mg/l	
Lead	mg/l	
Napthalene	mg/l	

Allen Park Clay Mine

Ground Water Monitoring Data

Additional Water Quality Parameters

Well: 5-D Up Gradient

Date Sampled: 08-10-81

Parameter	Units	
Static	Feet	605.89
COD	mg/l	3.80
Iron	mg/l	(0.030
Chloride	mg/l	128.
Sulfate	mg/l	240.
Sp. Conductance	umhos/cm	1550.
Sp Conductance	umhos/cm	
Sp Conductance	umhos/cm	
Sp Conductance	umhos/cm	
pH 1		9.60
pH 2		
pH 3		
pH 4		
TOC 1	mg/l	9.88
TOC 2	mg/l	
TOC 3	mg/l	
TOC 4	mg/l	
Calcium	mg/l	18.8
Sodium	mg/l	180.
Magnesium	mg/l	160.
Bicarbonate	mg/l	675.
Ammonia-Nitrogen	mg/l	0.300
Nitrogen-Nitrate	mg/l	(0.002
Nitrogen-Nitrite	mg/l	(0.100
Phenols	mg/l	0.021
Chromium	mg/l	(0.010
Cadmium	mg/l	(0.020
Lead	mg/l	0.050
Napthalene	mg/l	

Date Sampled: 05-06-82 07-14-82 10-26-82

Parameter	Units			
Static	Feet	605.12	605.45	604.64
COD	mg/l			
Iron	mg/l	1.70	1.20	0.880
Chloride	mg/l	140.	150.	140.
Sulfate	mg/l	190.	200	70.0
Sp. Conductance	umhos/cm	2160.	1990.	1785.
Sp. Conductance	umhos/cm	2109.	1918.	1800.
Sp. Conductance	umhos/cm	2121.	1937.	1791
Sp. Conductance	umhos/cm	2100.	1954.	1860.
pH 1		7.32	7.44	10.2
pH 2		7.28	7.50	10.2
pH 3		7.31	7.67	10.2
pH 4		7.32	7.60	10.2
TOC 1	mg/l	6.08	21.0	21.0
TOC 2	mg/l	5.00	18.0	20.0
TOC 3	mg/l	5.00	13.0	9.00
TOC 4	mg/l	6.00	20.0	33.0
Calcium	mg/l			
Sodium	mg/l	85.0	86.0	180.
Magnesium	mg/l			
Bicarbonate	mg/l			
Ammonia-Nitrogen	mg/l			
Nitrogen-Nitrate	mg/l	0.010	0.250	<0.010
Nitrogen-Nitrite	mg/l			
Phenols	mg/l	<0.004	<0.004	<0.004
Chromium	mg/l	<0.005	0.016	0.019
Cadmium	mg/l	0.006	<0.003	<0.003
Lead	mg/l	0.018	<0.018	0.091
Napthalene	mg/l			

Allen Park Clay Mine

Ground Water Monitoring Data

Additional Water Quality Parameters

Well: 5-D Up Gradient

Date Sampled: 04-26-83 06-24-83

Parameter	Units		
Static	Feet	604.24	605.44
COD	mg/l		27.0
Iron	mg/l		1.70
Chloride	mg/l		160.
Sulfate	mg/l		140
Sp. Conductance	umhos/cm		1600.
Sp. Conductance	umhos/cm		1600.
Sp. Conductance	umhos/cm		1600.
Sp. Conductance	umhos/cm		1600.
pH 1			8.00
pH 2			8.00
pH 3			8.00
pH 4			8.00
TOC 1	mg/l		7.00
TOC 2	mg/l		11.0
TOC 3	mg/l		9.00
TOC 4	mg/l		8.00
Calcium	mg/l		38.0
Sodium	mg/l		110.
Magnesium	mg/l		240.
Bicarbonate	mg/l		600.
Ammonia-Nitrogen	mg/l		0.830
Nitrogen-Nitrate	mg/l		0.020
Nitrogen-Nitrite	mg/l		<0.020
Phenols	mg/l		
Chromium	mg/l		<0.020
Cadmium	mg/l		
Lead	mg/l		0.100
Napthalene	mg/l		

Allen Park Clay Mine

Ground Water Monitoring Data

Additional Water Quality Parameters

Well: 5-D Up Gradient

Date Sampled. 04-17-84

Parameter	Units	
Static	Feet	603.93
COD	mg/l	<4.00
Iron	mg/l	0.118
Chloride	mg/l	150.
Sulfate	mg/l	386.
Sp. Conductance	umhos/cm	1700
Sp. Conductance	umhos/cm	
Sp. Conductance	umhos/cm	
Sp. Conductance	umhos/cm	
pH 1		9.3
pH 2		
pH 3		
pH 4		
TOC 1	mg/l	3.60
TOC 2	mg/l	
TOC 3	mg/l	
TOC 4	mg/l	
Calcium	mg/l	11.0
Sodium	mg/l	110.
Magnesium	mg/l	160.
Bicarbonate	mg/l	450.
Ammonia-Nitrogen	mg/l	0.600
Nitrogen-Nitrate	mg/l	<0.020
Nitrogen-Nitrite	mg/l	<0.020
Phenols	mg/l	
Chromium	mg/l	<0.020
Cadmium	mg/l	
Lead	mg/l	
Napthalene	mg/l	

Allen Park Clay Mine

Ground Water Monitoring Data

Additional Water Quality Parameters

Well: 7-D Down Gradient

Date Sampled: 06-10-81

Parameter	Units	
Static	Feet	541.81
COD	mg/l	1.90
Iron	mg/l	0.030
Chloride	mg/l	150.
Sulfate	mg/l	1300.
Sp. Conductance	umhos/cm	2250.
Sp. Conductance	umhos/cm	
Sp. Conductance	umhos/cm	
Sp. Conductance	umhos/cm	
pH 1		10.0
pH 2		
pH 3		
pH 4		
TOC 1	mg/l	7.88
TOC 2	mg/l	
TOC 3	mg/l	
TOC 4	mg/l	
Calcium	mg/l	378.
Sodium	mg/l	120.
Magnesium	mg/l	24.8
Bicarbonate	mg/l	0.0000
Ammonia-Nitrogen	mg/l	0.750
Nitrogen-Nitrate	mg/l	0.100
Nitrogen-Nitrite	mg/l	0.002
Phenols	mg/l	0.023
Chromium	mg/l	0.018
Cadmium	mg/l	0.028
Lead	mg/l	0.050
Napthalene	mg/l	

Allen Park Clay Mine

Ground Water Monitoring Data

Additional Water Quality Parameters

Well: 7-D Down Gradient

Date Sampled: 05-06-82 07-14-82 18-26-83

Parameter	Units			
Static	Feet	589.68	583.05	586.35
COD	mg/l	200.	160.	260.
Iron	mg/l	3.30	20.0	3.40
Chloride	mg/l		160.	140.
Sulfate	mg/l	850.	1000.	860.
Sp. Conductance	umhos/cm	1800.	2604.	2435.
Sp. Conductance	umhos/cm			
Sp. Conductance	umhos/cm			
Sp. Conductance	umhos/cm			
pH 1		9.80	10.0	10.0
pH 2				
pH 3				
pH 4				
TOC 1	mg/l	85.0	31.0	49.0
TOC 2	mg/l			
TOC 3	mg/l			
TOC 4	mg/l			
Calcium	mg/l	270.		
Sodium	mg/l			260.
Magnesium	mg/l	48.0		
Bicarbonate	mg/l	39.0		
Ammonia-Nitrogen	mg/l			0.630
Nitrogen-Nitrate	mg/l			0.080
Nitrogen-Nitrite	mg/l			0.020
Phenols	mg/l			
Chromium	mg/l	0.028		
Cadmium	mg/l			
Lead	mg/l			0.440
Naphthalene	mg/l			

Allen Park Clay Mine

Ground Water Monitoring Data

Additional Water Quality Parameters

Well: 7-D Down Gradient

Date Sampled: 06-24-83

Parameter	Units	
Static	Feet	592.05
COD	mg/l	160.
Iron	mg/l	14.8
Chloride	mg/l	180.
Sulfate	mg/l	1160.
Sp. Conductance	umhos/cm	2200.
Sp. Conductance	umhos/cm	2200.
Sp. Conductance	umhos/cm	2200.
Sp. Conductance	umhos/cm	2200.
pH 1		10.6
pH 2		10.8
pH 3		10.8
pH 4		10.8
TOC 1	mg/l	49.0
TOC 2	mg/l	28.0
TOC 3	mg/l	42.0
TOC 4	mg/l	21.0
Calcium	mg/l	450.
Sodium	mg/l	150.
Magnesium	mg/l	18.8
Bicarbonate	mg/l	40.8
Ammonia-Nitrogen	mg/l	0.940
Nitrogen-Nitrate	mg/l	0.040
Nitrogen-Nitrite	mg/l	(0.020
Phenols	mg/l	
Chromium	mg/l	(0.020
Cadmium	mg/l	
Lead	mg/l	1.00
Napthalene	mg/l	

Time of Execution: 06/19/84 18:40.3 edt Tue

Allen Park Clay Mine

Ground Water Monitoring Data

Additional Water Quality Parameters

Well: 7-D Down Gradient

Date Sampled: 04-17-84

Parameter	Units	
Static	Feet	592.84
COD	mg/l	130.
Iron	mg/l	0.530
Chloride	mg/l	1c0.
Sulfate	mg/l	2500.
Sp. Conductance	umhos/cm	2400.
Sp. Conductance	umhos/cm	
Sp. Conductance	umhos/cm	
Sp. Conductance	umhos/cm	
pH 1		9.90
pH 2		
pH 3		
pH 4		
TOC 1	mg/l	35.0
TOC 2	mg/l	
TOC 3	mg/l	
TOC 4	mg/l	
Calcium	mg/l	280.
Sodium	mg/l	110.
Magnesium	mg/l	15.0
Bicarbonate	mg/l	0.0000
Ammonia-Nitrogen	mg/l	0.900
Nitrogen-Nitrate	mg/l	(0.020
Nitrogen-Nitrite	mg/l	0.020
Phenols	mg/l	
Chromium	mg/l	(0.020
Cadmium	mg/l	
Lead	mg/l	
Napthalene	mg/l	

Allen Park Clay Mine

Ground Water Monitoring Data

Additional Water Quality Parameters

Well: 10-D Down Gradient

Date Sampled: 08-18-81

Parameter	Units	
Static	Feet	601.81
COD	mg/l	7.00
Iron	mg/l	0.240
Chloride	mg/l	150.
Sulfate	mg/l	2100.
Sp. Conductance	umhos/cm	3000.
Sp. Conductance	umhos/cm	
Sp. Conductance	umhos/cm	
Sp. Conductance	umhos/cm	
pH 1		7.80
pH 2		
pH 3		
pH 4		
TOC 1	mg/l	7.80
TOC 2	mg/l	
TOC 3	mg/l	
TOC 4	mg/l	
Calcium	mg/l	370.
Sodium	mg/l	98.0
Magnesium	mg/l	200.
Bicarbonate	mg/l	225.
Ammonia-Nitrogen	mg/l	0.500
Nitrogen-Nitrate	mg/l	(0.100
Nitrogen-Nitrite	mg/l	0.002
Phenols	mg/l	0.009
Chromium	mg/l	0.010
Cadmium	mg/l	0.020
Lead	mg/l	0.050
Napthalene	mg/l	